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An assessment of the future of resource recovery from municipal waste for the years 1972 to 1990, based on the assumption there would be no Federal legislation to stimulate resource recovery to 1990. Key methods of recovery are examined with emphasis on large-scale system recovery techniques (primarily energy/material recovery by SMSA). Data on material collection, recycling centers and current scrap dealers are also included. The results are summarized by material for the resources studied: glass, ferrous metals, aluminum, plastics, rubber, paper.

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BASE LINE FORECASTS
OF
RESOURCE RECOVERY, 1972 TO 1990

Final Report

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1975

This report has been reviewed by the Resource Recovery Division, OSWMP, EPA, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

An environmental protection publication (SW-107c) in solid waste management series.

PREFACE

The study was carried out under EPA Contract 68-01-0793 as MRI Project No. 3736-D, "Resource Recovery Forecasts to 1990." The basic objective of the study was to develop forecasts of recovery of materials common to municipal solid waste for the 1972 to 1990 period. These materials are: ferrous metals, glass, aluminum, plastic, rubber and paper. In addition, a similar recovery forecast was developed for mixed municipal waste. The principal resource recovery options identified as the most viable were materials recycling and energy/fuel recovery. The forecasts were made under the contractual "given" that specific federal legislation would not occur to stimulate or discourage recycling.

In general, we found that resource recovery from municipal waste is likely to be significant in the years ahead. Because the study took place in a period of unusually dynamic change in energy supply and natural resource use, we were unable to evaluate fully the impact of these rapid changes on our long-range forecasts. However, we believe that our forecasts will prove to be conservative for resource recovery when the implications of the energy and resource supply "crisis" are fully understood.

The project was under the general direction of Mr. Gary R. Nuss, Manager, Economics and Management Science Division. Mr. William E. Franklin, Manager, Resource and Environmental Economics Programs, was project leader and a principal analyst. Other analysts on the study were Mr. David Hahlen, Mr. William Park, Mr. Michael Urie and Mr. James Cross.

The EPA project officer was Mr. Michael Loube, who provided valuable guidance and direction to the research team.

Approved for:

MIDWEST RESEARCH INSTITUTE

Gary R. Nuss

Gary R. Nuss, Director
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CHAPTER I

INTRODUCTION

We are a materials-using nation, and our economy, with its huge industrial base, clearly reflects this fact. To feed this "materials economy," natural resources of the nation (and world) are extracted from the earth, processed and refined, and converted into useful products. Any product put into use serves a value or intended function to the user. However, all products also lose their usefulness over time (a few seconds to a span of decades) and then become discards or solid waste.

The quantity of solid wastes generated is linked directly to the total use of materials in economic activity and the rate at which they are discarded as waste. The only ways to reduce the amount of solid waste disposal without reducing the rate of use or reuse of materials are to: (1) extend the life of the products we use, and/or (2) usefully recover for recycling or other purposes waste materials that would otherwise be disposed of in dumps, landfills and incinerators.

Resource recovery is a viable alternative to waste disposal. In 1973 the strains of increasing demand on the natural resource base improved the economic potential of resource recovery. Commercial resource recovery projects previously "years away" are now in the design stage. Large scale resource recovery units will be in operation by 1975 or 1976, and more will follow.

This study was done in a period of unusual pressure on resource supply and industrial capacity to produce materials from virgin resources. In fact, in 1973 the prices of secondary materials were the highest they had ever been and supplies in some cases fell below short-term demand. Likewise, export demand was contributing to the scarcity of raw materials supplies in the U.S.A. At the same time resource recovery seemed to have suddenly "come of age," as several significant commercial projects were announced during the study period. Added to this was an "energy crisis" which seemed to burst upon the nation suddenly, although ample evidence of this phenomenon was available years ago. Conservation, a word often used in reference to environmental groups and other groups seeking to preserve wilderness areas, became a broad concern, not only of the industry, but of the public and of government as well.

A realistic assessment of the future of resource recovery from municipal waste is the subject of this report--to establish "base line" forecasts of resource recovery for the period 1972 to 1990.

PURPOSE OF STUDY

This study was designed by the Office of Solid Waste Management Programs of the Environmental Protection Agency to serve as a background document for resource recovery forecasts for the period 1972 to 1990. The purpose of the research was to establish "base line" data for resource recovery which is a counterpart to solid waste generation.

Once base line forecasts are established for industrial resource recovery requirements and solid waste recovery potential, then there is a basis for testing various alternatives that might alter the pattern of resource recovery--to stimulate resource recovery from municipal waste and thus reduce solid waste disposal requirements.

RESEARCH OBJECTIVES AND SCOPE

The objectives of this research work were to develop to 1990 a supply and demand analysis of resource recovery from municipal solid waste. The objectives included a forecast of: (1) the quantity of municipal waste generated; (2) the recovery of resources from mixed municipal wastes; (3) the recovery of specific manufactured materials commonly found in solid wastes; (4) the total recoverable quantity of each of the seven waste materials; (5) the source of waste generated categorized as: residential, commercial/institutional and industrial waste. The materials included in the study are: glass, ferrous metals, aluminum, plastics, paper and rubber.

A number of related steps were required to develop basic data to meet the primary objectives of the study. First, an analysis of municipal solid waste trends were considered from the standpoint of: waste generation, composition, and resource recovery potential to 1990. Included in this analysis was the recovery of materials for recycling and energy conversion. Second, the major recovery modes were considered: centralized waste processing facilities, transfer station separation, separate collection centers and source separation of materials (including present scrap industry operations). Forecasts of actual resource recovery were developed to 1990 with the principal emphasis on centralized waste processing units to recover energy and materials.

Third, each of the specific materials was considered separately and in detail for a recovery profile to 1990. This included analysis of each of the materials for forecasts of total demand for finished products; generation rates of waste for each; availability of these materials from residential, commercial/institutional, and industrial sources; analysis of waste generation rates in selected geographic and population units; present recovery and forecast demand for recycled materials. The resource recovery forecasts developed were then reconciled to produce a common forecast of resource recovery to 1990.

Specific attention was given to major products or processes within each materials group that constitute the most significant component of municipal wastes; e.g., glass containers, plastics packaging, and metal cans. Paper for all uses was covered completely. Market factors that might affect the forecasts were also considered, such as trends in the use of materials and containers, packaging practices, intermaterial competition and other factors.

Basic Assumptions of the Study

There was one contractual "given" for the study--the base line forecasts were to be developed assuming there would be no federal legislation to stimulate resource recovery to 1990. In other words, the objective of the study was to develop a "base line" forecast of what resource recovery would actually be in 1990 as a consequence of forces at work outside the federal establishment. However, pollution control regulations or other federal actions were included, including those that might impact resource recovery in the future. (Presumably the effect of any proposed federal initiative to stimulate resource recovery could be tested against the base line data.)

The evidence for the observations that follow is not yet solid enough to document thoroughly. Thus it was necessary to make some broad judgmental assumptions based on our current understanding of some rather fundamental forces at work in economics, resource utilization and environmental quality improvement.

First, we assumed that the effects of the "energy crisis" and resource supply shortage are principally of short-range duration (2-4 years) and that there will be an adequate supply of raw materials without interruption of basic demand trends for products. At the same time it appears likely that recycling of materials from solid waste will become more prevalent to meet supply requirements. We have also assumed that the "energy crisis" is more likely to manifest itself as an inducement to resource recovery than to a basic change in demand patterns for plastic products, rubber, and textiles which are derived largely from hydrocarbons. In other words, a "flow-through" concept in which hydrocarbons are used first as a manufactured product, (e.g., plastic), with recovery of the hydrocarbon energy value after discard, is the more likely pattern to 1990. However, process energy conservation may also encourage recycling practices whenever significant energy savings can be demonstrated in using recycled material as opposed to virgin materials.

In addition we have assumed that the general economy will continue to have significant real growth, averaging in the range of 4 percent per year over a long period and that population growth will increase from 212 million in 1973 to 261 million in 1990, as found in the Bureau of the Census, Series P-2, No. 476, published in February 1972.

Within the solid waste sector itself, we have assumed, on the basis of conclusions from other work, that resource recovery has been demonstrated to be feasible under certain circumstances and that major metropolitan areas will consider it a viable alternative to traditional disposal in the years ahead. Also, we assumed that regional resource recovery planning and implementation now under way will proceed.

Much of the basic data in this study presume that the nation is now entering an era in which we will be more resource conscious, but in which the historic patterns of demand will maintain their overall trends. The makeup of the raw materials that meet demand, however, could shift toward resource recovery on a gradual but steady basis, and units of government will enter the raw materials supply business (including energy) via solid waste recovery processing alternatives.

Report Organization

The balance of this report is organized around the identifiable materials groups. Chapter II summarizes the forecasts of resource recovery for mixed municipal wastes including the recovery of materials discussed in later chapters. Next, Chapter III addresses the potential for centralized processing of mixed municipal wastes and energy recovery from the organic fraction.

Chapter IV is a short introduction to the specific materials studied in detail. It gives the purpose of the material-by-material forecasts and other general introduction to the analyses of specific industrial requirements for recycled materials.

Chapters V through X cover the demand forecasts for materials found in solid waste that were studied separately. There is a chapter each on: ferrous metals, aluminum, glass, plastics, rubber and paper. Each chapter develops the demand forecast for the industry to 1990; the generation of solid waste; the source of solid waste; the quantity of solid waste that appears to be recoverable; and our forecast of resource recovery for that particular material as recycling or other recovery alternatives such as energy. Included is the manner in which recovery from waste will take place--centralized waste processing, collection centers, source separation, etc.

Finally there is a series of appendices that give back-up detail for several subjects of interest. Appendix A is the back-up detail for packaging materials and configurations where intermaterials competition takes place, i.e., steel, aluminum, glass and plastics. Particular emphasis is given to beverage and food packaging because the two together make up most of the packaging materials requirements for the materials cited above.

Appendix B is a discussion of the trends in steel scrap usage. Appendix C is a special section on trends in the use of scrap in the aluminum industry to 1990. Appendix D is an analysis of plastic resin demand by end use providing back-up detail to Chapter VIII. Appendix E contains back-up analysis and detail on the paper Chapter (X). References and data sources are given in bibliographic form in Appendix F.

CHAPTER II

OVERVIEW OF RESOURCE RECOVERY FORECASTS TO 1990

OVERVIEW OF STUDY FINDINGS

By 1990, 40 metropolitan areas in the United States will be operating 60 centralized resource recovery plants, processing about 49 million tons of mixed municipal solid wastes annually. These plants are expected to recover: 2.8 million tons of ferrous metal; 0.4 million tons of aluminum; 0.6 million tons of glass; 0.5 million tons of paper; and 486 x 10^{12} Btu of energy for use in power generation during 1990. The wastes processed by these resource recovery operations will represent approximately 25 percent of the 200 million tons of mixed municipal solid wastes expected to be generated that year.

The centralized large resource recovery systems in 1990 will be concentrated primarily along the East and West Coasts and in the North Central states. However, virtually every state with a city of SMSA having a population base in excess of 300,000 will likely have at least one large resource recovery system in operation.

In addition to resources recovered through central processing facilities, there will be additional recovery from municipal wastes at disposal sites and other collection points. This recovery will take place via source separation/collection; collection centers; separation at transfer stations and separation at disposal sites. The quantities recovered via noncentralized modes from municipal wastes are forecast to be: 0.3 million tons of ferrous metals, including appliances; 0.15 million tons of aluminum; 0.25 million tons of glass; and 2.0 million tons of paper recovered in conjunction with solid waste collection.

These two combined major recovery modes will result in a total recovery, from 200 million tons of waste generated, of 486 x 10^{12} Btu of energy; 3.1 million tons of ferrous metal; 0.5 million tons of aluminum; 0.85 million tons of glass, and 2.5 million tons of paper recovered in conjunction with solid waste.

The chief impetus for resource recovery will come primarily from two directions: (1) the increasing cost of disposal by sanitary landfill, brought about by rapidly rising land and operating costs and a scarcity of suitable landfill sites that can be purchased and developed; and (2) the decreasing net cost of solid waste processing in energy-recovery systems, a result of the increasing cost of conventional fuels and the comparable increases in the value of recovered energy. Materials recovery will add impetus to this basic trend.

RESOURCES RECOVERED FROM MIXED MUNICIPAL SOLID WASTES

In recovery systems recovering organic materials for fuel or energy uses, ferrous metals are easily removed and sold as scrap, and this magnetic separation process is an integral part of any resource recovery system. Additionally, aluminum is expected to be recovered in view of its high scrap value, and by 1985 essentially all aluminum will be processed for recovery from mixed wastes that are also being processed for use as fuel. The separation of ferrous and nonferrous metals from the organic portion of the solid waste stream leaves glass, which has a relatively low unit value, but nevertheless can be a worthwhile commodity when a suitable local market exists, especially in the form of a glass container manufacturing plant. Paper will also be removed, but generally prior to entering a centralized waste-processing facility.

Typical mixed municipal solid wastes in 1975 will contain at "median" waste generation rates of 140 million tons, 11.5 percent glass by weight; 8.5 percent ferrous metal; and 1.4 percent nonferrous metal, chiefly aluminum. The combustible portion of the waste (paper, plastics, rubber, textiles, yard waste, garbage, etc.) has an energy value of about 5,000 Btu per pound (4,500 on the basis of raw refuse). By 1990, the percent content of these recoverable materials will have changed, based upon the changes in total waste generated and the MRI forecasts of the quantity of metal and glass in total demand. For example, by 1990 our estimates are as follows: ferrous metal, 8.2 percent; nonferrous metal, 1.5 percent; and glass, 8.4 percent. The percentages of inorganic materials will decrease while the organic materials, especially plastics and textiles, will increase. The proportion of paper in waste will decrease slightly. We have assumed that the Btu content of raw municipal waste will increase over time--from 9×10^6 Btu/ton in 1972 to 9.3×10^6 in 1980; 9.6×10^6 in 1985; and 10.0×10^6 in 1990.

A 1,000 ton per day (300,000 ton per year) resource recovery plant will have the following recovery potential annually:

Material	1972	1975	1980	1985	1990
Ferrous metal (tons)	21,675	21,675	21,165	21,675	20,910
Nonferrous metal (tons)	1,365	1,560	1,755	2,145	2,340
Glass (tons)	19,695	20,475	20,085	18,135	16,380
Combustibles (energy)	221,700	219,900	220,800	222,600	225,900
Total Recoverable	264,435	263,610	263,805	264,555	265,530
Nonrecoverable	35,565	36,390	36,195	35,455	34,470

These values were calculated based on the average composition of the waste for each base year less an unrecoverable residue that would be a yield loss or ash. The recovery efficiency for each material is given in the summary tables that follow. The high recovery potential for organics is based upon processing for fuel or energy products; otherwise the only recoverable material in organics is paper.

Tables 1 through 7 summarize the quantities of these five resources expected to be recovered in various years over the 1972-1990 period.

The data in these tables were derived from MRI's estimates of the number of waste-processing facilities that would be in operation each 5-year period for the recovery of energy from mixed waste and from the recovery of materials for recycling via centralized waste processing and other recovery modes such as collection centers and separation at transfer stations. The values for the inorganic materials recovered are developed in later sections of the report and are only summarized here.

Table 1 summarizes projected recovery in centralized waste processing facilities. Here it is assumed that the amount of each material "available" is based upon the national rate of waste generation developed in each materials chapter, i.e., the demand for the material adjusted to the amount entering the waste stream in any given year.

The recovery rate for ferrous metals, aluminum and glass is based on MRI estimates of mechanical recovery efficiency of separation techniques and on the marketability of any material. For example, ferrous metals are considered to be recoverable at 85 percent mechanical efficiency and marketable from all locations. Aluminum recovery technology is assumed to be viable by 1985 with an estimated recovery efficiency of 65 percent. Aluminum is fully marketable where recovered. Glass is recovered only where glass container plants are nearby, and color sorted at a recovery efficiency of 70 percent by 1990. Energy is recovered at its full content which means that the entire organic fraction is utilized as fuel; this is expressed the same way as fossil fuel equivalent, i.e., before any heat losses in the energy conversion use itself.

In Table 2 the inorganic materials recovered from other wastes not centrally processed are summarized. This is recovery from transfer stations, from collection centers and via source separation/collection techniques in the solid waste management system itself. Most of these show a limit of 250,000 tons which represents the practical limits of these separation options and the fact that more solid waste goes through central processing systems each year.

TABLE 1

SUMMARY OF RESOURCES RECOVERED FROM MIXED MUNICIPAL SOLID WASTES
AT CENTRAL PROCESSING PLANTS, 1972 TO 1990
(In 1,000 tons and 10^{12} Btu)

Category	1972	1975	1980	1985	1990
Total solid waste generated	130,000	140,000	160,000	180,000	200,000
Total solid waste processed	Neg.	2,100	6,600	24,000	48,600
% solid waste processed	Neg.	1.5	4.1	13.3	24.3
Resources available/recovered in waste processed:					
Energy 10^{12} Btu - available	Neg.	18.9	61.4	230.4	486.0
Energy 10^{12} Btu - recovered	Neg.	18.9	61.4	230.4	486.0
Glass available	0	220	680	2,230	4,080
Glass recovered	0	10	100	350	600
Ferrous metal available	0	150	465	1,705	3,315
Ferrous metal recovered	0	127	395	1,450	2,815
Aluminum available	0	18	62	250	560
Aluminum recovered	0	1	12	165	365
Paper available	0	650	2,100	7,650	16,350
Paper recovered	0	Neg.	50	200	500

Neg. = Negligible
Source: Midwest Research Institute

TABLE 2

SUMMARY OF RESOURCES RECOVERED FROM MIXED MUNICIPAL SOLID WASTES NOT CENTRALLY PROCESSED, 1972 TO 1990

(In 1,000 tons)

Category	1972	1975	1980	1985	1990
Total solid waste generated	130,000	140,000	160,000	180,000	200,000
Total solid waste not centrally processed	130,000	137,900	153,400	156,000	151,400
Resources available/recovered in waste not processed					
Glass available	13,200	14,280	15,720	14,370	12,820
Glass recovered	275	265	275	250	250
Ferrous metal available	11,100	11,550	12,535	13,445	13,085
Ferrous metal recovered	70	158	195	265	320
Aluminum available	900	1,182	1,438	1,650	1,740
Aluminum recovered	27	50	93	115	145
Paper available	41,500	41,450	48,450	49,650	50,800
Paper recovered	50	300	600	1,000	2,000

Source: Midwest Research Institute

TABLE 3

SUMMARY OF RESOURCES RECOVERED FROM MIXED MUNICIPAL SOLID WASTES, 1972 TO 1990

(In 1,000 tons 10^{12} Btu and percent)

Category	1972	1975	1980	1985	1990
Energy - 10^{12} Btu	Neg.	18.9	61.4	230.4	486.0
Recovery - % of available	Neg.	1.5	4.1	13.3	24.3
Glass recovery	275	275	375	600	850
Recovery - % of available	2.8	1.8	2.3	3.6	5.0
Ferrous metals recovery	70	285	590	1,715	3,135
Recovery - % of available	0.6	2.4	4.5	11.3	19.1
Aluminum recovery	27	51	105	280	510
Recovery - % of available	3.0	4.2	7.0	14.7	22.2
Paper recovery[a/]	50	300	650	1,200	2,500
Recovery - % of available	0.1	0.7	1.3	2.1	3.7

Source: Midwest Research Institute

[a/] Energy recovery from paper included under Energy.

TABLE 4

SUMMARY OF GLASS PROCESSING/RECOVERY FOR MIXED MUNICIPAL WASTE, 1972 TO 1990

(In 1,000 tons and percent)

Category	1972	1975	1980	1985	1990
Total solid waste generated	130,000	140,000	160,000	180,000	200,000
Glass available	13,200	14,500	16,400	16,600	16,900
% glass of total waste	10.1	10.5	10.3	9.3	8.4
Total waste processed (central facilities)	0	2,100	6,600	24,000	48,600
Glass content	0	220	680	2,230	4,080
Glass processed for recovery	0	20	170	540	860
Resource recovered - glass	0	10	100	350	600
Resource not recovered - glass	0	175	455	1,350	2,315
Total waste not centrally processed	130,000	137,900	153,400	156,000	151,400
Glass content	13,200	14,280	15,720	14,370	12,820
Glass recovered	275	265	275	250	250
Glass not recovered[a]	12,925	14,025	16,025	16,000	16,050
Total resource recovery - glass	275	275	375	600	850
Percent recovery of total - glass	2.8	1.8	2.3	3.6	5.0

Source: Midwest Research Institute

[a] Includes glass from central processing facilities not recovered.

TABLE 5

SUMMARY OF FERROUS METALS PROCESSING/RECOVERY FOR MIXED MUNICIPAL WASTE, 1972 TO 1990

(In 1,000 tons and percent)

Category	1972	1975	1980	1985	1990
Total solid waste generated	130,000	140,000	160,000	180,000	200,000
Ferrous metal available[a]	11,100	11,700	13,100	15,200	16,400
% ferrous metal of total waste	8.5	8.5	8.3	8.5	8.2
Total waste processed (central facilities)	Neg.	2,100	6,600	24,000	48,600
Ferrous metal content[b]	0	150	465	1,705	3,315
Ferrous metal recovered at 0.85 yield	0	127	395	1,450	2,815
Ferrous metal not recovered	0	23	70	255	500
Total waste not centrally processed	130,000	137,900	153,400	156,000	151,400
Ferrous metal content[c]	11,100	11,550	12,535	13,495	13,085
Ferrous metal recovered	70	158	195	265	320
Ferrous metal not recovered[d]	11,030	11,415	12,510	13,485	13,265
Total resource recovery - ferrous metal	70	285	590	1,715	3,135
Percent recovery of total - ferrous metal	0.6	2.4	4.5	11.3	19.1

Source: Midwest Research Institute

[a] Includes ferrous metal in appliances.

[b] Excludes ferrous metal in appliances.

[c] Includes ferrous metal in appliances.

[d] Includes ferrous metal not recovered from central processing facilities.

TABLE 6

SUMMARY OF ALUMINUM PROCESSING/RECOVERY FOR MIXED MUNICIPAL WASTE, 1972 TO 1990

(In 1,000 tons and percent)

Category	1972	1975	1980	1985	1990
Total solid waste generated	130,000	140,000	160,000	180,000	200,000
Aluminum available[a]	900	1,200	1,500	1,900	2,300
% aluminum of total waste	0.7	0.9	0.9	1.0	1.2
Total waste processed (central facilities)	Neg.	2,100	6,600	24,000	48,600
Aluminum content	0	18	62	250	560
Aluminum processed for recovery	0	2	20	250	560
Aluminum recovered at 65% yield	0	1	12	165	365
Aluminum not recovered	0	17	50	85	195
Total waste not centrally processed	130,000	137,900	153,400	156,000	151,400
Aluminum content	900	1,182	1,438	1,650	1,740
Aluminum recovered	27	50	93	115	145
Aluminum not recovered[b]	873	1,149	1,395	1,620	1,790
Total resource recovery - aluminum	27	51	105	280	510
Percent recovery of total - aluminum	3.0	4.2	7.0	14.7	22.2

Source: Midwest Research Institute

a/ Aluminum packaging and aluminum in appliances.

b/ Includes aluminum not recovered from central processing facilities.

TABLE 7

SUMMARY OF PAPER PROCESSING/RECOVERY FOR MIXED MUNICIPAL WASTES, 1972 TO 1990

(In 1,000 tons and percent)

Category	1972	1975	1980	1985	1990
Total solid waste generated	130,000	140,000	160,000	180,000	200,000
Paper available[a]	41,550	42,100	50,550	57,300	67,150
% paper of total waste	32.0	30.1	31.6	31.8	33.6
Total waste processed (central facilities)	Neg.	2,100	6,600	24,000	48,600
Paper content	0	650	2,100	7,650	16,350
Processed for fiber recovery	0	Neg.	100	400	1,000
Paper recovered at 0.50 yield	0	0	50	200	500
Paper recovered as energy	0	650	2,000	7,250	15,350
Paper not recovered	0	0	50	200	500
Total waste not centrally processed	130,000	137,900	153,400	156,000	151,400
Paper content	41,500	41,450	48,450	49,650	50,800
Paper recovered	50	300	600	1,000	2,000
Resource not recovered - paper[b]	41,500	41,150	47,900	48,850	49,300
Total resource recovery - paper fiber	50	300	650	1,200	2,500
Total resource recovery - energy	Neg.	650	2,000	7,250	15,350
Total paper recovery	50	950	2,650	8,450	17,850
Percent recovery of total paper	0.1	2.2	5.2	14.7	26.6

Source: Midwest Research Institute.

a/ Includes only waste paper reaching waste collection, processing or disposal facilities.

b/ Includes paper not recovered from central processing facilities.

The grand totals for resource recovery are then given in Table 3, which are simply the values in the previous two tables added together. It shows that total resource recovery from municipal waste in 1990 is forecast to be 437 x 10^{12} Btu of energy; 3.1 million tons of ferrous metal; 0.5 million tons of aluminum; and 0.85 million tons of glass. In addition, there will be 2.5 million tons of paper recovered directly from municipal waste systems.

Tables 4 through 6 give the composite recovery values for each of the inorganic materials--ferrous metals, aluminum and glass. These data were also partly given in Tables 1 through 3. Table 7 summarizes paper recovery.

The values given in each table are presented in summary form only. The data on which these values were developed are related to the recovery potential of centralized waste processing facilities and the demand/recoverability/marketability characteristics of each material as developed in detail in the succeeding chapters.

CHAPTER III

RESOURCE RECOVERY FROM MUNICIPAL SOLID WASTE

FORECASTING RESOURCE RECOVERY FROM MIXED MUNICIPAL WASTES

This chapter explores the fundamental economic considerations involved in analyzing the relative desirability of resource recovery; identifies the quantity and location of economically recoverable wastes; estimates the quantity of wastes that will actually be processed for recovery; and translates these results into the specific resources recovered.

The sanitary landfill is presently, in most parts of the United States, the lowest cost environmentally acceptable means of disposal for mixed municipal solid wastes. In areas where suitable landfill sites are either unavailable or prohibitive in cost, incineration is the most common alternative.

However, in locations where incineration offers an economical or necessary alternative to landfill, some form of resource recovery is almost sure to prove superior to both. Recovery of the organic fraction of the mixed solid waste stream for use as a supplemental fuel for utility boilers offers distinct economic advantages over conventional incineration for disposal.

In the 18-year period from 1972 to 1990, most municipalities will have to find new places to dispose of their wastes because existing dumps will be closed, landfills will become full and existing incinerators will become inadequate or require major renovation. Thus, disposal choices will be forced upon nearly every governmental unit in this period. Will the choice be resource recovery or conventional disposal?

MRI's analysis indicates that in the long term, economics is the key factor which will determine whether disposal or recovery will be pursued. The most important element of cost in solid waste disposal by landfill is the cost of land acquisition, and the annual charges associated with the capital tied up in land. For resource recovery systems utilizing the combustible portion of the wastes as a coal or petroleum supplementing fuel source, the most important economic factor is the value of the recovered fuel.

Thus, when the sanitary landfill is compared with an energy recovery system, low land prices favor the sanitary landfill, while high energy values favor the fuel recovery concept.

Certainly the direction, if not the magnitude, of land prices and energy values in all parts of the United States is clearly up; both of these established trends favor resource recovery, with the final economics depending on local price levels and growth rates in these two items.

In this study, the cost of disposal by sanitary landfill has been related to different land purchase prices. Similarly, the net costs (or net income) of disposal associated with an energy recovery system have been related to different recovered energy values. Combining these two relationships establishes a "break-even" point between the two concepts, based on locally prevailing land costs and energy values. The "break-even" land price can be calculated as a function of energy values, or the "break-even" energy values as a function of land costs.

Energy values and farm real estate prices were compiled on a state-by-state basis, and projections were made at 5-year intervals through 1990 for each state. (Note that farm land values represent an absolute minimum cost for purchased property since most landfills would be close enough to metropolitan areas where land values would normally be higher than farm land values.) The estimated values were then inserted in the break-even equations to establish the most feasible disposal alternative at each point in time. Following this procedure, the approximate year in which resource recovery would become economically feasible in each state (if at all) was determined. Then, the major metropolitan areas within the various states--those sufficiently large to generate the required quantities of mixed solid wastes to support a full-scale resource recovery operation--were delineated, and estimates were made of the number of resource recovery plants in each state and the quantities of the different resources to be recovered.

The following sections in Chapter II describe the analysis procedures in some detail, and present the resulting estimates of the potential for resource recovery in the United States through 1990.

BASIC RESOURCE RECOVERY ECONOMICS

The Economics of Sanitary Landfill for Disposal

MRI estimates that the variable costs (i.e., out of pocket costs) associated with disposal by sanitary landfill average about $2.35 per ton for a 1,000 ton per day (300,000 ton per year) operation; the balance of disposal cost is directly attributable to the investment in land, and amounts to approximately 6 percent of the total capital tied up in land. This assumes that, on termination of the landfill project, the land value will be at least equal to its original cost, and that only interest and carrying costs are charged against the land account.*

Figure 1 shows the relationship between net solid waste disposal costs and the cost per acre for land disposal sites. This relationship has been developed from the cost data presented in Table 8 and can be expressed mathematically as follows:

$$C_{SLF} = 2.35 + 0.96\ L$$

where C_{SLF} is the cost per ton of disposal via sanitary landfill and L is the cost of the landfill site, in thousands of dollars per acre. The assumptions are made that approximately twice as much land will be acquired as will actually be devoted to landfill, and that the landfill site will accommodate some 5,000 tons of mixed refuse per acre over a 20-year period. The $2.35, as stated before, represents all costs exclusive of the carrying charges on the land. The second factor is the equation--0.96 L--which is simply the number of acres required to handle 300,000 tons per year of waste for 20 years (2,400), times a multiplier (2) to reflect total acquisition costs in excess of raw farm land prices times a 6 percent carrying charge times the base land cost (L) in dollars per acre, divided by the annual quantity of wastes to be disposed (300,000 tons): 2,400 x 2.0 L x 0.06/300,000 = 0.00096L (where L is in dollars/acre) or 0.96L (with L in $1,000/acre).

Most communities in the U.S. will require additional disposal sites in the 1972 to 1990 period as old landfills are closed out, incinerators become obsolete and as metropolitan areas expand in size.

The Economics of Resource Recovery

Since the sanitary landfill is generally the lowest cost (in dollars) solid waste disposal method, alternatives are normally sought only when suitable landfill sites are prohibitively expensive or unavailable. In such a situation, incineration for disposal has been the usual choice for disposal.

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* Municipalities seldom account for capital tied up in land in the "traditional" business economics approach. Capital expenditures are usually handled separately, accounted for separately, and the cost of owning capital assets is seldom charged against the total cost of operation of a disposal site. Nonetheless, the costs are real and are becoming recognized as such in local governments.

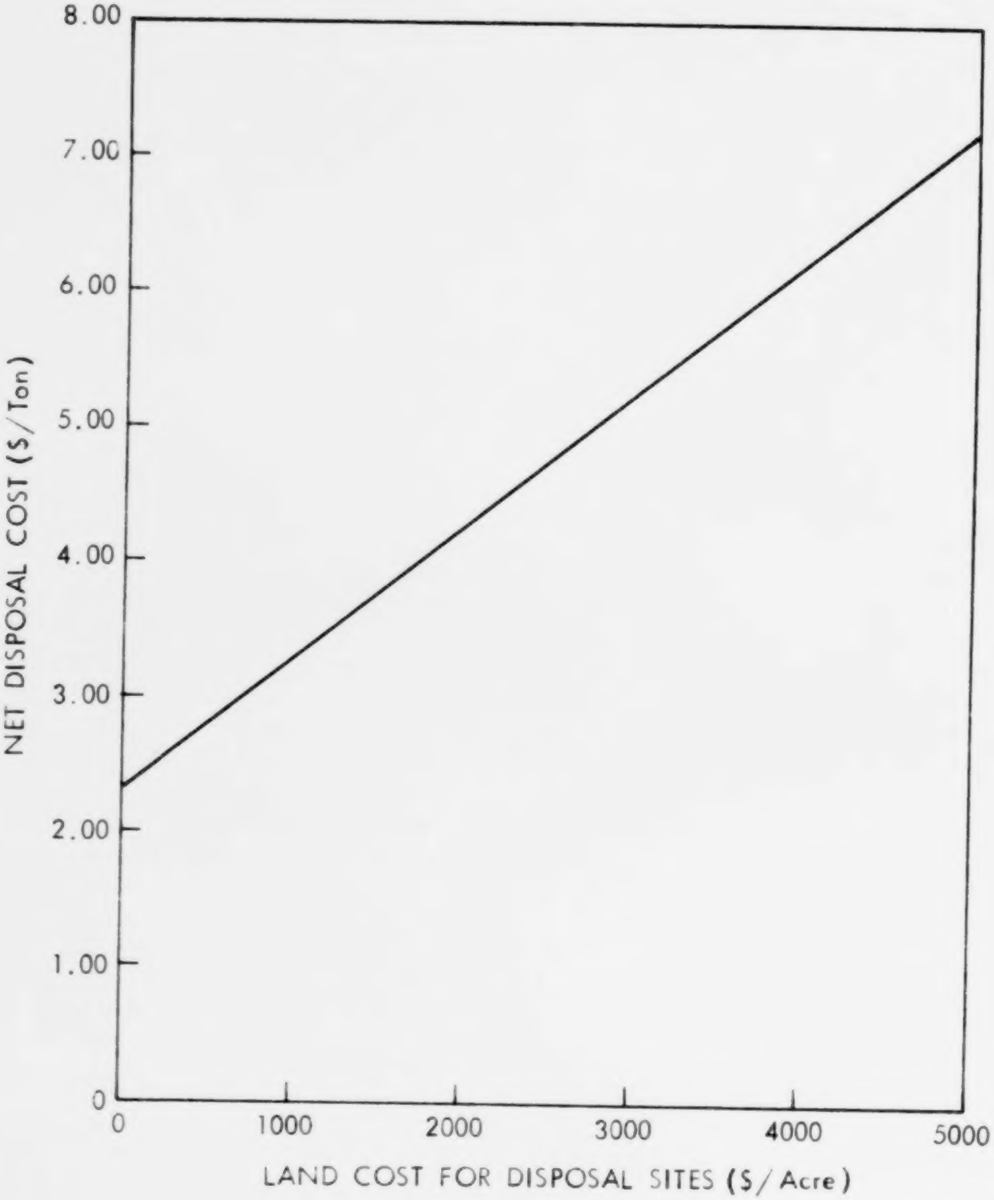

Figure 1 - Relationship Between Net Solid Waste Disposal Costs and Land Cost

TABLE 8

COMPARATIVE ECONOMICS OF SOLID WASTE DISPOSAL BY LANDFILL AND RECOVERY AS ENERGY

(1,000 ton/day, 300,000 ton/year operation, 20-year life

	Energy (Fuel) Recovery System		Sanitary Landfill (Land Cost = $1,000/acre)	
	($)	($/Ton)	($)	($/Ton)
Capital Requirements				
Amortized Investment	1,315,000		200,000	
Fixed Investment	9,300,000		950,000	
Recoverable Investment				
Land	450,000		4,800,000	
Working Capital	300,000		125,000	
Total	750,000		4,925,000	
Total Capital Requirement	11,365,000		6,075,000	
Annual Costs of Operation				
Direct Operating Costs	1,200,000	4.00	505,000	1.68
Fixed Costs	180,000	0.60	40,000	0.13
Capital Charges				
Land at 6%/annum	27,000	0.09	288,000	0.96
Other Charges	1,203,000	4.01	160,000	0.53
Total	1,230,000	4.10	448,000	1.49
Total Annual Cost	2,610,000	8.70	993,000	3.30
Value of Recovered Resources				
Ferrous Metal (20,000 tons at $12.00)	240,000	0.80		
Energy (Fuel) (2.7 x 10^{12} Btu at $0.50/$10^6$)	1,350,000	4.50		
Total Resource Value	1,590,000	5.30	0	0
Net Operating Cost	1,020,000	3.40	993,000	3.30

Source: Midwest Research Institute.

However, if in a given area incineration is an acceptable alternative to the sanitary landfill, additional economics can usually be achieved by practicing some form of resource recovery. Probably the most logical approach in these cases is to recover the heat generated by burning the solid wastes, in conjunction with the recovery of certain inorganics which will not burn and should be removed prior to combustion anyway.

Today, the most viable resource recovery technique for mixed municipal waste appears to be some combination of energy and materials recovery. At present, resource recovery systems will likely experience a net operating cost; its "profits" will be derived by a reduced operating cost over the alternate disposal option such as incineration or landfill. (In the future, resource values could rise enough so an actual profit is made.)

The total cost of operating a 1,000 ton per day system designed to recover the energy in the organics by combustion of mixed solid wastes is estimated at $8.70 per ton, of which direct operating costs account for $4.00 and the balance consists of fixed costs and capital-related charges (Table 8). Ferrous metals are removable via magnetic separation, reducing the net disposal cost to $7.90 per ton at a value of $12.00 per ton for ferrous scrap. The value of the energy or organic materials such as paper recovered, then, will be the primary determinant of the ultimate net solid waste disposal cost.

The simplest and lowest net cost resource recovery technique today is converting mixed waste to a fuel. A 1,000 ton per day, 300,000 ton per year operation will be able to produce some 2.7×10^{12} Btu of energy (at 4,500 Btu per pound of raw refuse) in the form of a fuel suitable for use by utility plants in electric power generation. The value of this solid waste derived fuel will depend on the availability and cost of conventional fossil fuels (especially coal) in the local area. To be conservative and to take account of risk and capital investment required by the user, this value should be expected to be somewhat less than the cost of conventional fossil fuels, averaging perhaps 20 percent less; in some areas, it could be worth more, but some discount from the fossil fuel equivalent is to be expected.

Figure 2 shows the relationship between net disposal costs via energy (fuel) and ferrous metals recovery, and the value of the fuel thus recovered.

This relationship, developed from the costs shown in Table 1, can be expressed as

$$C_{ER} = 7.90 - 9\,E$$

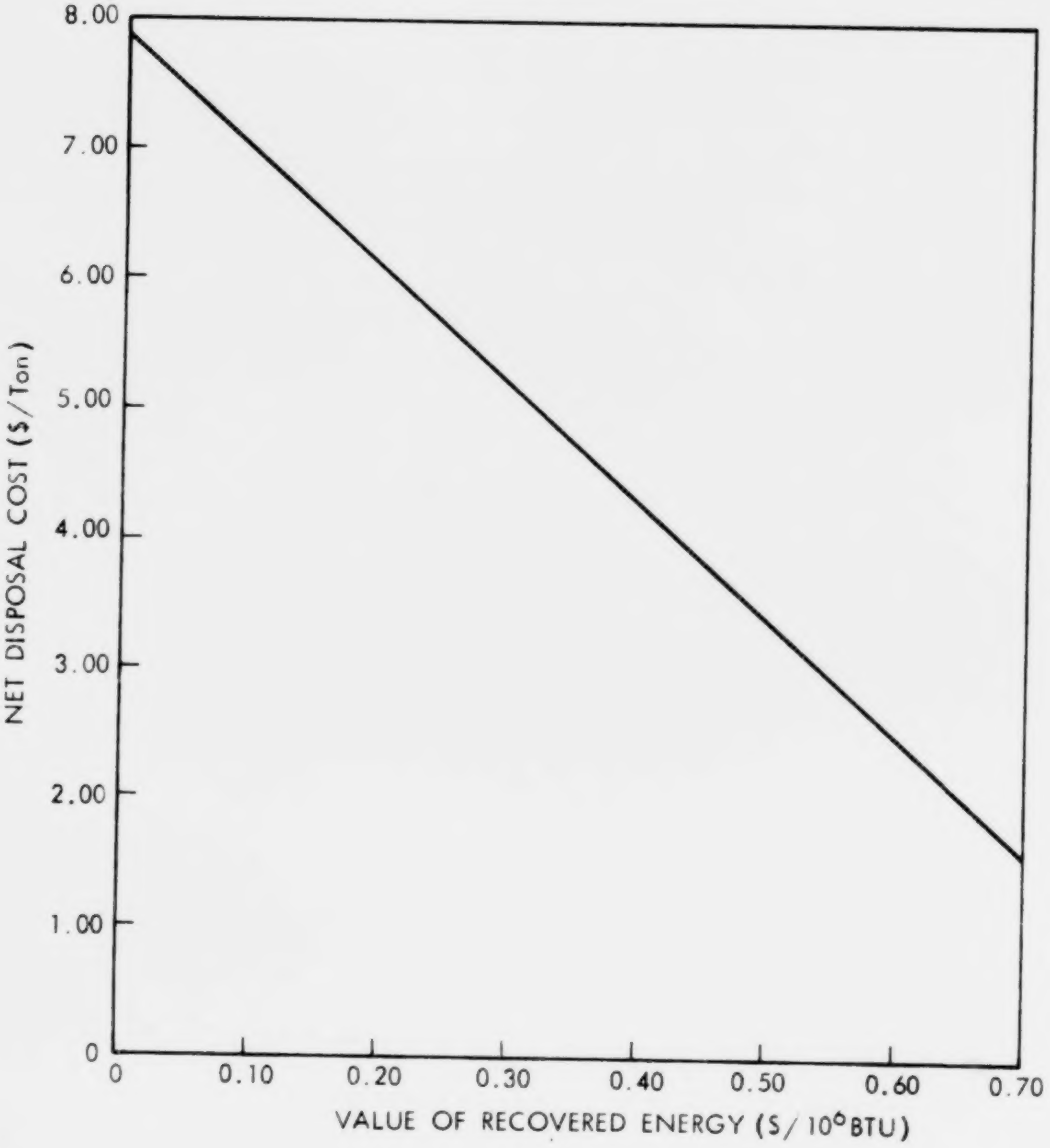

Figure 2 - Net Waste Disposal Cost Vs. Value of Energy

where C_{ER} is the net disposal cost per ton of mixed waste processed for use as fuel, and E is the value of the energy thus recovered, expressed in dollars per million Btu.* The $7.90 is the net disposal cost per ton excluding energy credits (Table 1); the 9 E represents energy credits on the recovery of 9 million Btu/ton of waste processed, at E dollars per million Btu.

Figure 2 shows that the net disposal costs approach zero at a fuel value of about $0.90 per million Btu. The actual fuel costs per utilities in some parts of the USA are already in excess of $0.50 per million Btu. Thus, the viability of energy recovery seems to be firm when alternative disposal costs are considered.

The Economics of Disposal Versus Resource Recovery

The comparative costs associated with solid waste disposal by sanitary landfill and in an energy recovery system are summarized in Table 8.

Since total actual disposal costs via sanitary landfill depend mainly on the cost of landfill sites and the chief variable affecting net operating costs in a resource recovery system is the value of the recovered energy, these two important variables--land cost and energy value--can be equated to describe a break-even situation. Other associated costs are relative and do not affect a decision to dispose or recover waste to the extent these two factors do. Land cost and energy value have been equated for a break-even situation in Figure 3, which indicates equivalent costs for any combination of the two variables. For example, the net solid waste disposal cost via resource (fuel) recovery with the recovered energy valued at $0.40/$10^6$ Btu, is equivalent to the cost of disposal by sanitary landfill when land costs $2,000 per acre.

The appropriate equations for relating land costs and energy values at the break-even point are as follows:

$$L = 5.78 - 9.38\ E$$

$$E = 0.62 - 0.11\ L$$

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* We do not preclude the recovery of other resources besides energy from the organic fraction of waste. In some situations the recovery of paper may be viable, for example. However, there is no other recovery option today that is so broadly applicable and also recovers value from the entire organic fraction of waste. Thus, energy represents maximum recovery of organics and minimum residue to be disposed of.

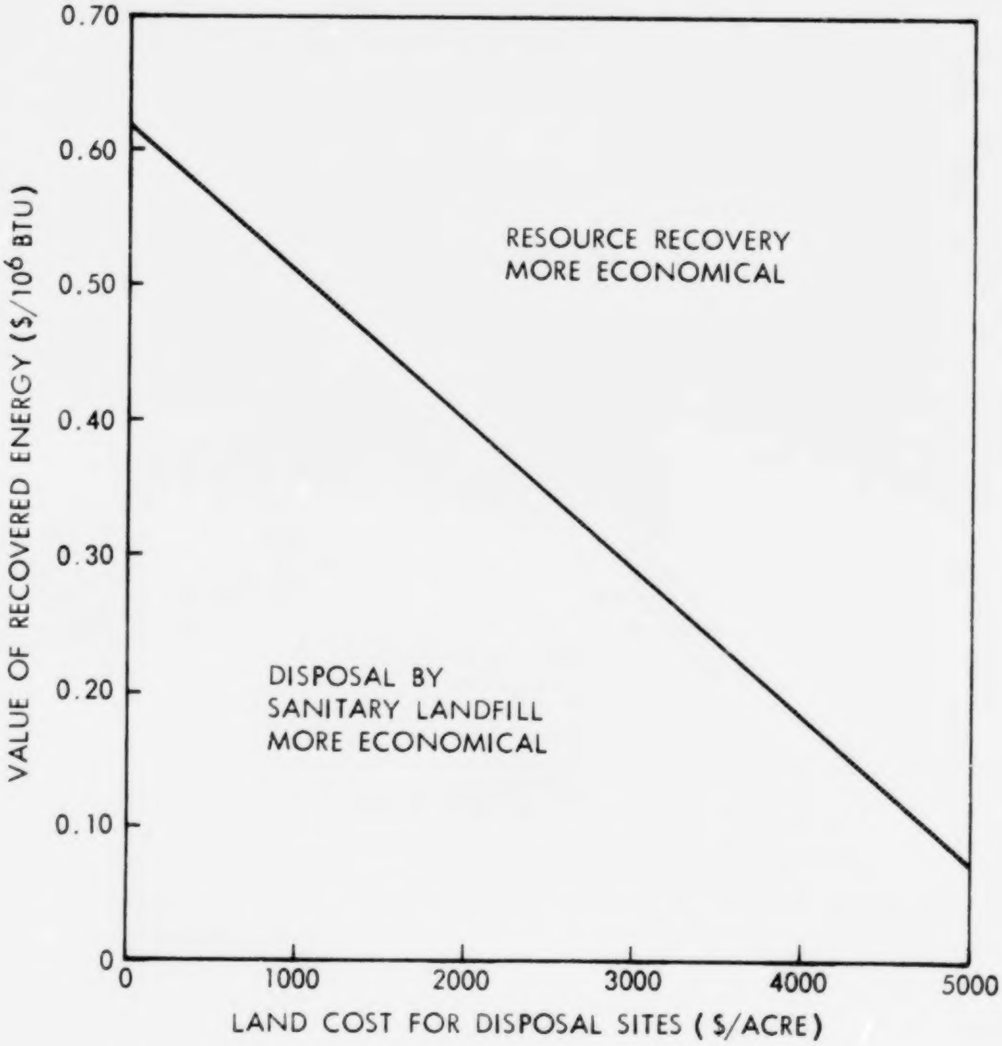

Figure 3 - Equivalence Between Land Cost and Energy Value

where, as before, L is the land cost for a disposal site (\$1,000 per acre) and E is the value of energy recovered as fuel (dollars/10^6 Btu).

Figure 3 provides a quick reference for determining the most economical alternative for handling solid wastes in a given area. If energy is valued at over \$0.60/10^6 Btu, for example, a resource recovery operation is probably justified regardless of land costs. And where land costs are relatively high--say in the \$3,000 per acre and over category--resource recovery should probably be considered even when conventional fuels are available locally at \$0.30/10^6 Btu or less.

How Land Values for Disposal Sites Were Determined

Farm real estate values in the United States (in 1973) averaged \$247 per acre, ranging from less than \$100 per acre in South Dakota, Montana, Arizona, Nevada, Wyoming and New Mexico, to more than \$1,000 per acre in Rhode Island, Connecticut and New Jersey.

For the U.S. as a whole, agricultural land values have risen an average of 6.9 percent annually over the past decade, and are expected to continue at a comparable rate for some time. Land value growth rates over the past 10 years have ranged from less than 5 percent annually (in California and South Dakota) to nearly 13 percent annually (in Georgia and Nevada), with the most rapidly rising land prices experienced in the northeastern parts of the United States.

Future land costs are not easily predictable, and recent increases have far exceeded the historical growth in farmland prices. The rapid increases in land values can be attributed both to financial speculation and to higher prices for farm commodities. For the purposes of this analysis, however, the growth rates established over the past 10 years have been used as the basis for projections from 1973 through 1990.

Assuming the historical rates to continue, farmland will cost more than \$10,000 per acre in New Jersey by 1990, while it will still be available for under \$200 per acre in New Mexico and Wyoming. Under the same trends in value for the U.S., farmland values will grow from their present \$247 per acre to \$394 in 1980; to \$550 in 1985; and to \$768 per acre in 1990. Figure 4 shows the expected increases in the national averages.

The increase in land costs will result in much higher costs for acquiring sanitary landfill sites, and subsequently in much higher costs of solid waste disposal by this means. Since land costs are highest in the most densely populated areas where solid waste generation is also highest, this gives a double-barreled effect toward favoring resource recovery.

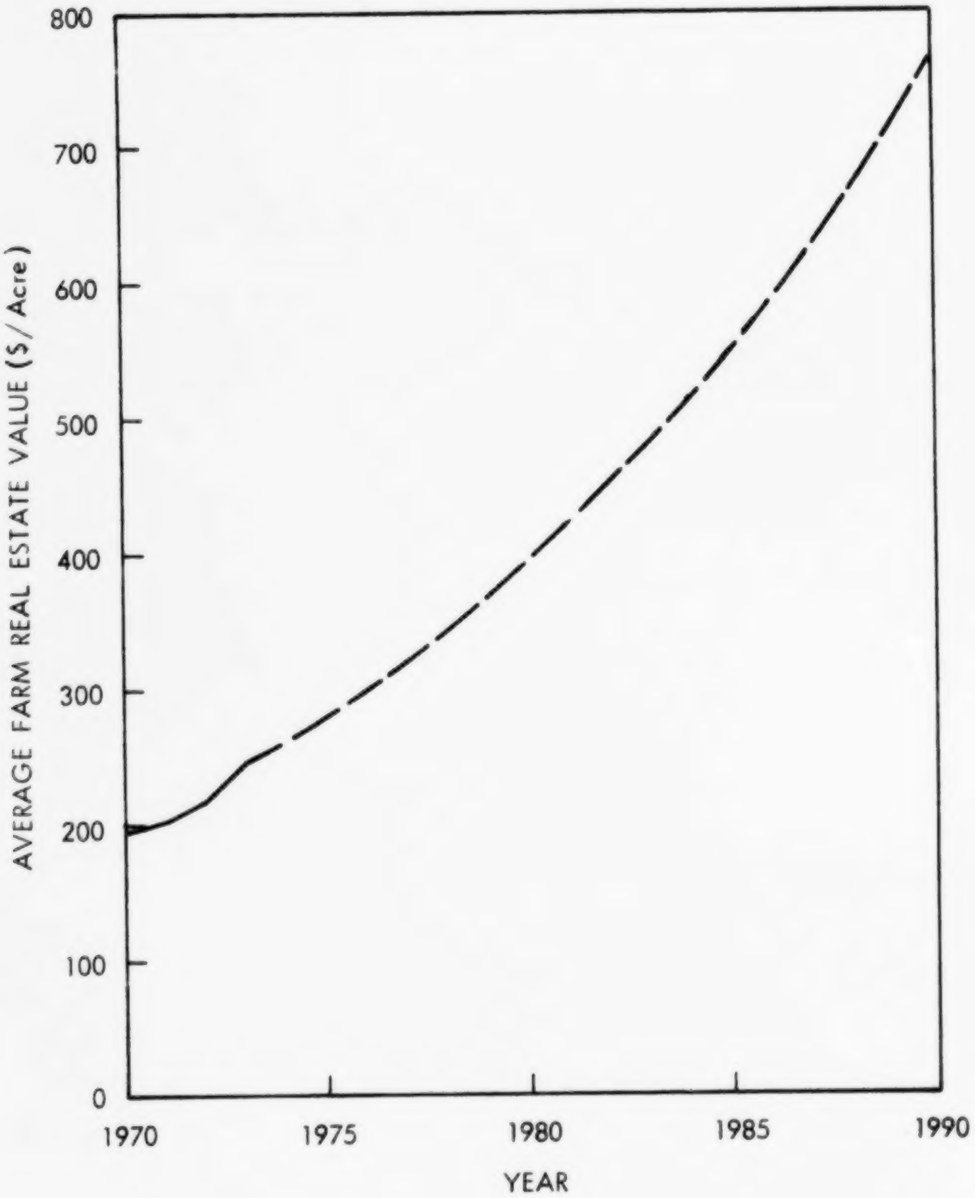

Figure 4 - Trend in Average Farm Real Estate Value, 1970-1990

In general, an overall price level for land can be estimated based on two types of locational factors:

1. Population density, and

2. Location of a land site with respect to population centers.

Figure 5 shows 1973 farm real estate values (in dollars per acre) plotted against population density on a state-average basis; Table 9 summarizes the data from which Figure 5 is plotted. A state with a population density of 100 persons per square mile, for example, would be expected to have farm real estate values falling in the \$350 to \$400 per acre range, while a state having a population density of 50 persons per square mile would average about \$100 per acre less for agricultural land; and doubling the population density (to 200 people per square mile) would mean that farmland values would be around \$550 per acre.

Said in another way, where people locate tends to bring greater value to nearby farmland. On a statewide average basis, the value of land used for agricultural purposes can be estimated as follows:

$$V = 380 \left(\frac{D}{100}\right)^{0.53}$$

where V is the average land value in dollars per acre and D is the state's population density in people per square mile.

In many areas where resource recovery appears uneconomical on a statewide average basis, there may be a number of locations within the state that offer attractive possibilities. To identify specific locations for resource recovery would require that resource values and land values be closely examined for the particular cities under consideration.

Realistic estimates of land value are hard to establish. Land prices fluctuate widely, year to year, area to area, and even season to season. Location determines land use, and land use determines land value.

The other locational factor is somewhat more specific, relating land value to its distance from a major population center. This relationship is shown in Figure 6.*

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* These data were based on actual market values of land in 1972 in the Kansas City metropolitan area.

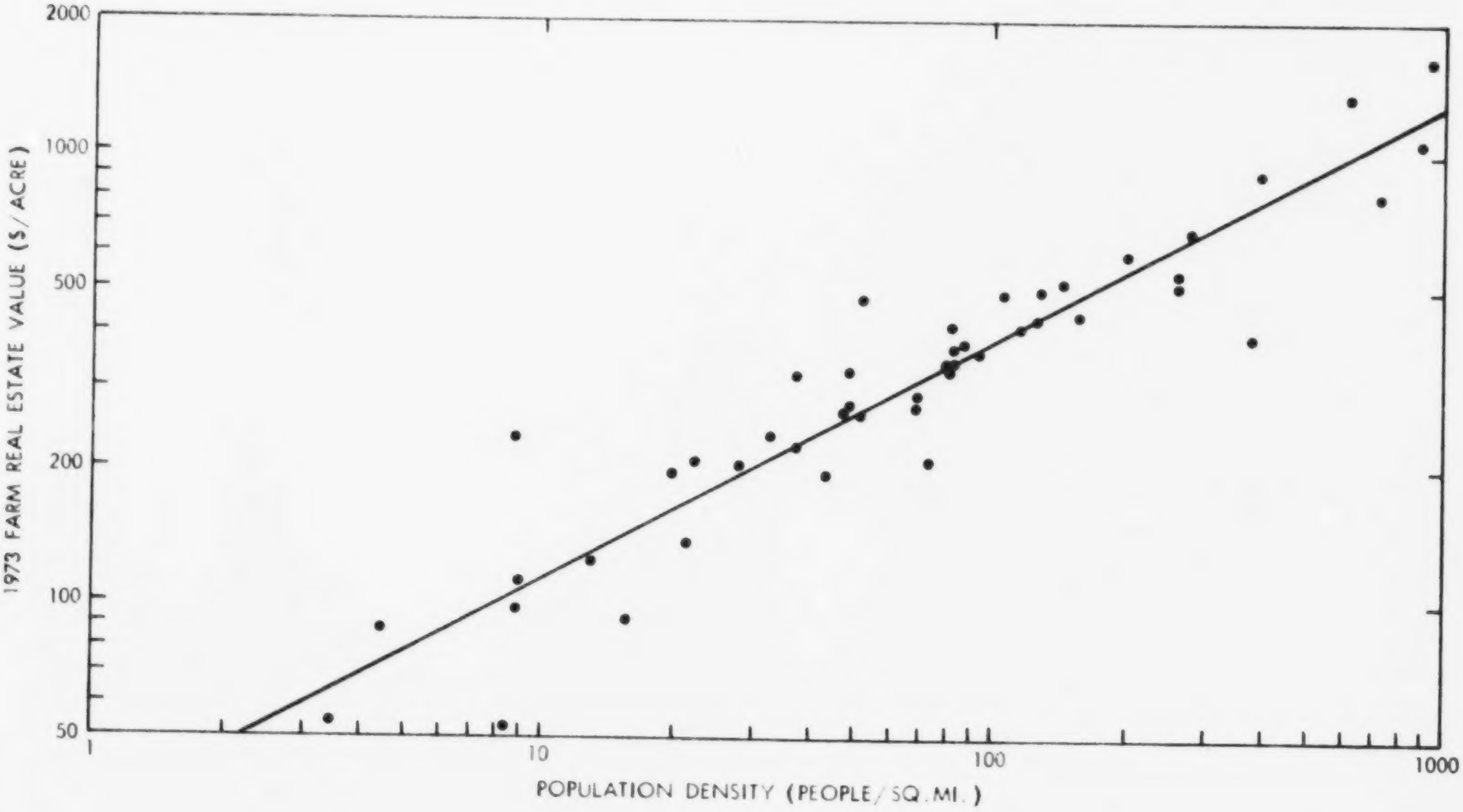

Figure 5 - Farm Real Estate Values Vs. Population Density

TABLE 9

FARM REAL ESTATE VALUES AND POPULATION DENSITIES BY STATES (1973)

Region and State	Land Cost ($/Acre)a/	Population Density (People/Sq. Mi.)b/	Region and State	Land Cost ($/Acre)a/	Population Density (People/Sq. Mi.)b/
New England			East South Central		
Maine	235	33	Kentucky	333	83
New Hampshire	368	84	Tennessee	363	98
Vermont	328	50	Alabama	274	69
Massachusetts	799	748	Mississippi	269	47
Rhode Island	1,036	928			
Connecticut	1,316	655	West South Central		
			Arkansas	321	35
Middle Atlantic			Louisiana	411	84
New York	390	390	Oklahoma	225	39
New Jersey	1,599	997	Texas	194	45
Pennsylvania	518	265			
			East North Central		
South Atlantic			Ohio	507	267
Delaware	663	291	Indiana	512	148
Maryland	888	421	Illinois	590	205
Virginia	404	122	Michigan	433	162
West Virginia	208	72	Wisconsin	336	84
North Carolina	483	107			
South Carolina	375	88	Mountain		
Georgia	340	82	Montana	76	5
Florida	423	135	Idaho	234	9
			Wyoming	54	4
West North Central			New Mexico	53	9
Minnesota	275	50	Arizona	93	17
Iowa	482	51	Utah	124	14
Missouri	289	69	Nevada	87	5
North Dakota	111	9	Colorado	138	22
South Dakota	97	9			
Nebraska	195	20	Pacific		
Kansas	203	28	Washington	262	54
			Oregon	204	23
			California	496	136

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a/ *Doane's Agricultural Report*, Vol. 36, No. 32-6, August 10, 1973.
b/ MRI calculation's based on 1970 Census Data.

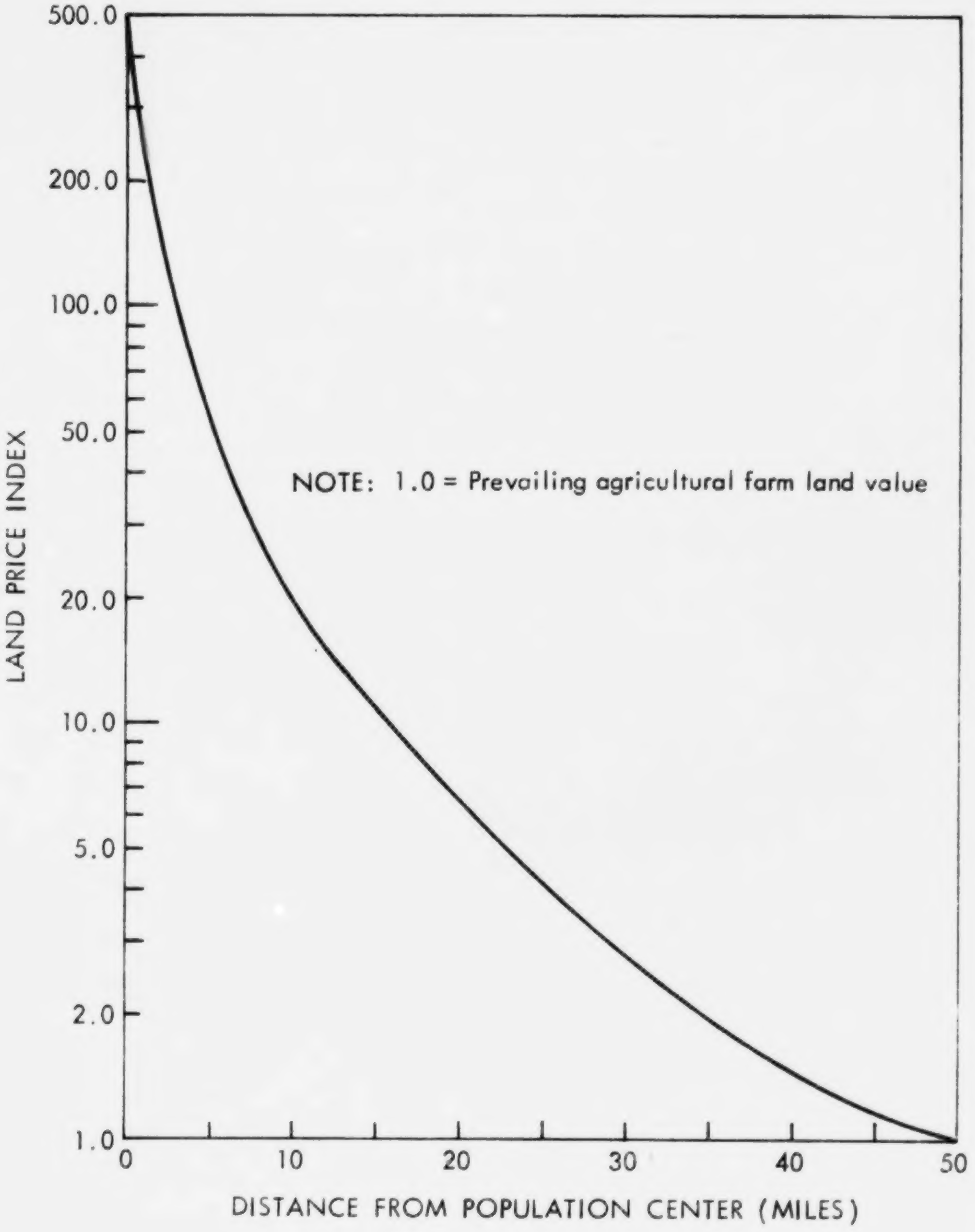


Figure 6 - Empirical Index of Land Price Vs.
Distance from Population Center

Here, it can be seen that land costs decrease as distance from a population center increases. At a 50-mile distance, land prices reflect their value for primarily agricultural use. Closer, they begin to include other, higher value uses, or at least the speculative possibility of future high-value use. Figure 6 relates land values at various distances between rural and urban (or suburban) land uses to the average value of raw farmland.

As shown in Figure 6, land that is 25 miles from the population center will be priced about 4.5 times as high as raw farmland (land price index approximately or equal to 4.5). Moving into within 10 miles raises the land price index to nearly 20.

This points out the problem a municipality faces in seeking a suitable landfill site. If farm real estate is valued at $300 per acre, it may still cost the city from $2,000 to $6,000 per acre for a landfill site within 10 to 20 miles, and it is unlikely that anything suitable could be found within 30 miles for less than $1,000 per acre.

The cost of operating a remote landfill facility is generally higher than for a close-in site, even considering the lower cost land. The added expense of maintaining a transfer station and transporting wastes over, say, a 100-mile distance, usually will offset any savings in land acquisition costs.

As land values rise, pushing up the costs of disposal by landfill, more and more areas will find resource recovery economically attractive, with the degree of attractiveness depending on the net costs associated with the particular resource recovery systems under consideration.

ECONOMICALLY RECOVERABLE SOLID WASTES

Energy Values and Land Costs

While increasing land costs will raise the total cost of solid waste disposal by landfill, rising energy values will reduce the net cost of solid waste disposal in energy recovery systems.

All three conventional fossil fuels--coal, oil and natural gas--will become increasingly expensive, as shown in Figure 7, making the energy recoverable from solid wastes more valuable.

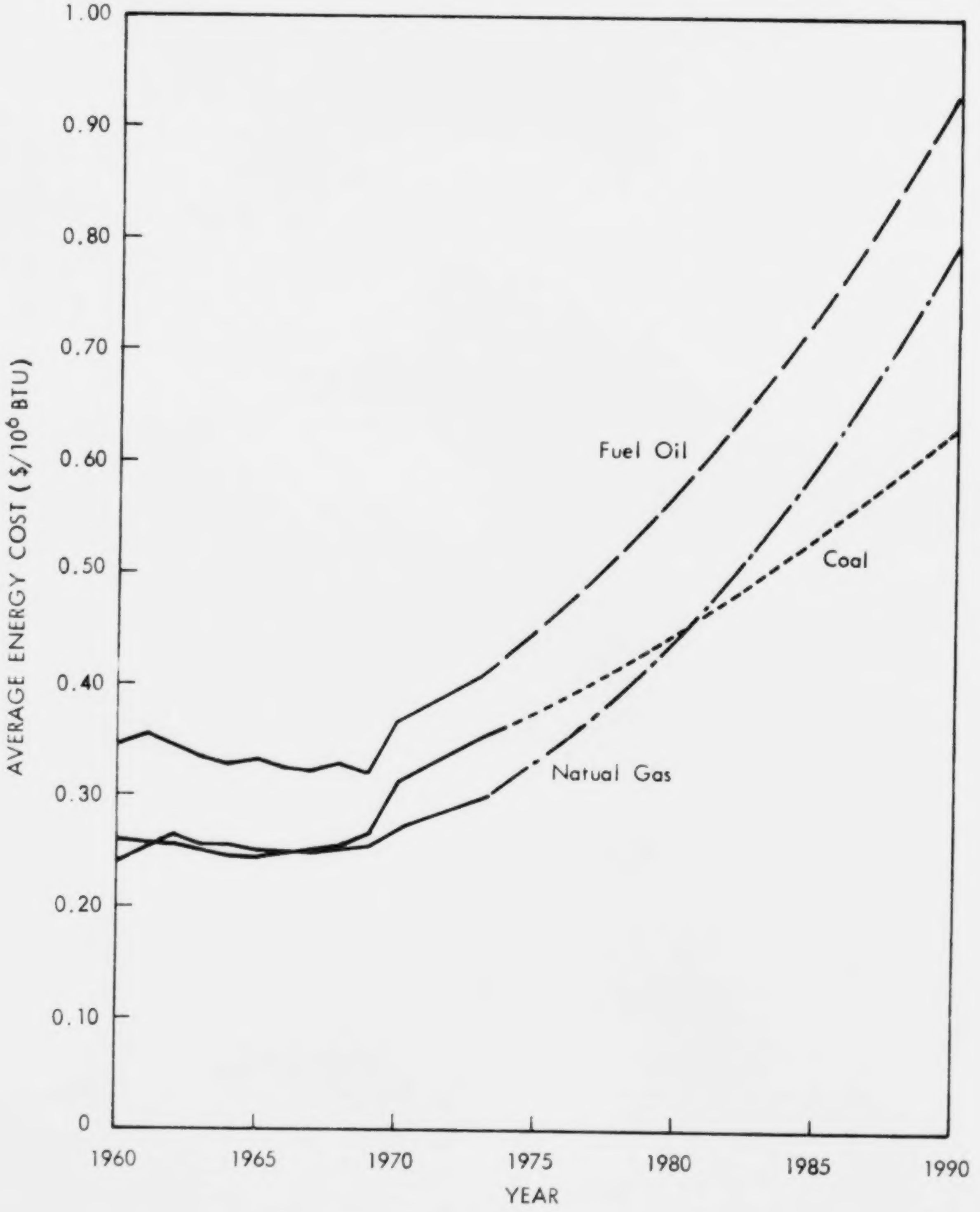


Figure 7 - Average Energy Cost of Fossil Fuels, 1960-1990

Source: Midwest Research Institute based on published fuel values.

Natural gas costs are expected to increase at a rate of 6 percent annually through 1990; fuel oil, at 5 percent annually; and coal at 3.5 percent annual rate. This will cause many electric utilities to shift in favor of coal over fuel oil and natural gas, which will also encourage the utilization of solid waste derived fuel. Nuclear energy will be used to a greater extent in many areas, but is unlikely to displace existing fuel sources by 1990.

The average as-burned cost of conventional fuels used by steam-electric generating plants in the United States presently ranges from about $0.20/10^6 Btu where low cost coal is locally available, to $0.50/10^6 Btu or more in some of the northern states which rely heavily on fuels brought in from distant sources. New plants using Wyoming coal will experience a cost of about $0.50/10^6 Btu. By 1990, the cheapest conventional fuel (usually coal) will cost up to $1.00/10^6 Btu, and will seldom be available for less than $0.50/10^6 Btu. Rising energy costs, coupled with increasing land costs (for disposal sites), will push many states into the "Resource Recovery More Economical" range in the next few years (Figure 3).

The present and projected land costs and energy values for the various states are summarized in Table 10, in which the energy value shown represents 80 percent of the estimated cost of conventional fossil fuels. These data are plotted in Figures 8 through 16 to show their effects in each state.

Where Resource Recovery Will Be Economically Feasible

When land costs and energy values are considered together for a particular location, the economics of waste disposal versus resource recovery can be established. The results of such an analysis on a state-by-state level, under two different assumptions, are given (Figures 17 and 18).

In one case (Figure 17), it was assumed that the energy recovered from solid wastes has a value equal to the cost of conventional fossil fuels, while in the other case (Figure 18), the recovered energy value is calculated at 20 percent less than other locally available fuels. The shaded areas in each figure indicate the years by which resource recovery will become economically feasible in the different states under these assumptions, based on the relationships between projected land and energy costs.

It is believed that the more conservative approach (Figure 18, where the recovered energy value equals 80 percent of the prevailing fuel cost) is the most realistic.

TABLE 10

ESTIMATED AVERAGE FARM LAND COSTS AND AVERAGE ENERGY VALUES BY STATE (1973-1990)
(In dollars per acre and cents per million Btu)

Region and State	1973		1980		1985		1990	
	Land Cost ($/Acre)	Energy Value (c/10^6 Btu)	Land Cost ($/Acre)	Energy Value (c/10^6 Btu)	Land Cost ($/Acre)	Energy Value (c/10^6 Btu)	Land Cost ($/Acre)	Energy Value (c/10^6 Btu)
New England								
Maine	235	30.2	441	42.4	700	55.8	1,082	69.1
New Hampshire	368	32.2	690	42.2	1,080	51.8	1,695	61.4
Vermont	328	40.3	615	51.3	970	61.8	1,511	72.4
Massachusetts	799	32.6	1,499	44.2	2,350	55.2	3,680	66.2
Rhode Island	1,036	32.9	1,943	45.5	3,050	57.8	4,771	70.1
Connecticut	1,316	32.2	2,468	43.1	3,900	53.8	6,061	64.5
Middle Atlantic								
New York	390	36.0	690	48.6	1,050	57.7	1,561	66.8
New Jersey	1,[illegible]99	35.4	3,491	47.7	6,100	56.6	10,650	65.4
Pennsylvania	[illegible]8	27.4	984	35.2	1,550	41.6	2,461	48.0
South Atlantic								
Delaware	663	35.4	1,079	46.4	1,550	54.2	2,162	61.9
Maryland	888	33.9	1,832	43.3	3,100	52.2	5,155	61.0
Virginia	404	30.9	711	39.3	1,060	47.4	1,592	55.4
West Virginia	208	21.2	403	27.0	650	32.6	1,035	38.1
North Carolina	483	31.1	771	39.6	1,080	47.8	1,502	55.8
South Carolina	375	31.0	686	41.5	1,050	50.4	1,623	59.3
Georgia	340	31.8	775	41.0	1,400	49.5	2,518	58.0
Florida	423	30.9	636	43.5	850	48.4	1,139	53.3

TABLE 10 (Continued)

Region and State	1973		1980		1985		1990	
	Land Cost ($/Acre)	Energy Value (c/10^6 Btu)	Land Cost ($/Acre)	Energy Value (c/10^6 Btu)	Land Cost ($/Acre)	Energy Value (c/10^6 Btu)	Land Cost ($/Acre)	Energy Value (c/10^6 Btu)
East South Central								
Kentucky	333	19.4	511	24.6	700	29.7	941	34.7
Tennessee	363	21.4	614	27.6	900	33.2	1,301	38.8
Alabama	274	25.2	498	32.2	760	38.8	1,167	45.4
Mississippi	269	23.6	473	35.4	710	43.1	1,060	50.7
West South Central								
Arkansas	321	23.6	583	35.5	900	49.5	1,368	63.5
Louisiana	411	18.8	682	28.2	980	39.4	1,405	50.6
Oklahoma	225	17.5	371	26.3	530	36.8	757	47.2
Texas	194	18.9	320	28.4	455	39.7	653	50.9
East North Central								
Ohio	507	25.4	798	32.3	1,100	39.0	1,527	45.5
Indiana	512	24.5	790	31.2	1,070	37.6	1,470	43.9
Illinois	590	26.8	864	34.8	1,130	41.7	1,490	48.6
Michigan	433	32.8	682	41.8	950	50.3	1,304	58.9
Wisconsin	336	34.1	587	44.0	870	53.1	1,303	62.2
West North Central								
Minnesota	275	30.3	403	40.6	530	51.1	694	61.6
Iowa	482	27.5	764	37.8	1,050	46.1	1,475	54.3
Missouri	289	24.0	512	31.6	780	37.7	1,157	43.8
North Dakota	111	15.7	166	19.9	220	24.0	294	28.2
South Dakota	97	29.6	132	40.3	165	48.6	205	56.7
Nebraska	195	27.0	309	38.6	430	50.2	597	61.6
Kansas	203	22.2	301	32.9	400	41.4	529	50.0

TABLE 10 (Concluded)

Region and State	1973 Land Cost ($/Acre)	1973 Energy Value (¢/10^6 Btu)	1980 Land Cost ($/Acre)	1980 Energy Value (¢/10^6 Btu)	1985 Land Cost ($/Acre)	1985 Energy Value (¢/10^6 Btu)	1990 Land Cost ($/Acre)	1990 Energy Value (¢/10^6 Btu)
Mountain								
Montana	76	21.4	124	27.8	175	33.5	248	39.2
Idaho	234	21.1	376	27.8	530	32.6	739	42.9
Wyoming	54	21.2	86	27.0	120	32.6	165	38.1
New Mexico	53	18.6	87	26.4	122	27.7	176	28.9
Arizona	93	27.0	171	39.8	260	43.9	409	48.0
Utah	124	20.7	213	28.5	310	32.6	459	36.6
Nevada	87	33.4	203	47.0	340	52.2	684	57.4
Colorado	138	23.0	212	31.0	275	37.4	390	43.8
Pacific								
Washington	262	35.4	394	49.8	530	65.5	706	81.2
Oregon	204	33.2	390	49.9	620	69.7	984	89.4
California	496	29.3	610	43.6	710	60.3	820	77.0

Sources: Doane's Agricultural Report, Vol. 36, No. 32-6, August 10, 1973. (Land cost for 1973.) Based on as-burned fuel costs reported in Steam-Electric Plant Factors, National Coal Association, 1973. Midwest Research Institute (1980, 1985, 1990).

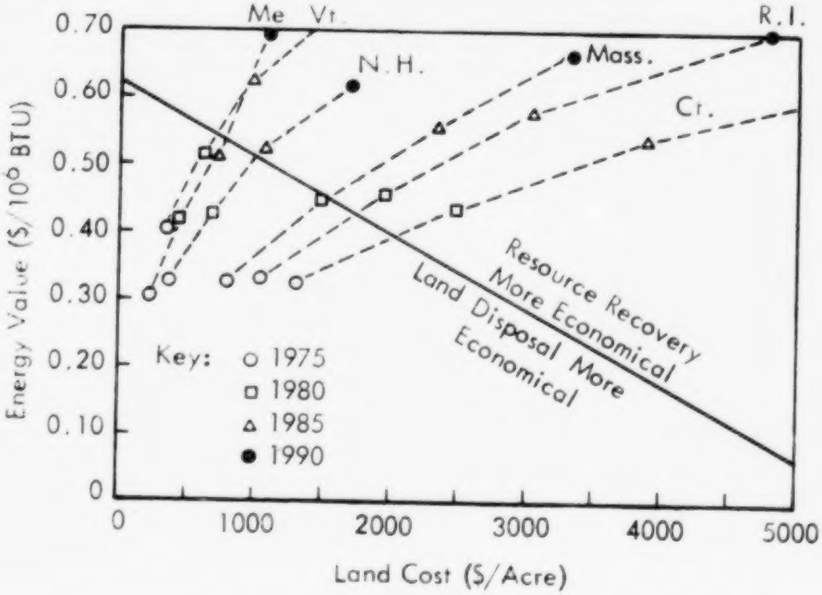


Figure 8 - Energy Values Vs. Land Cost in the New England States, 1972-1990

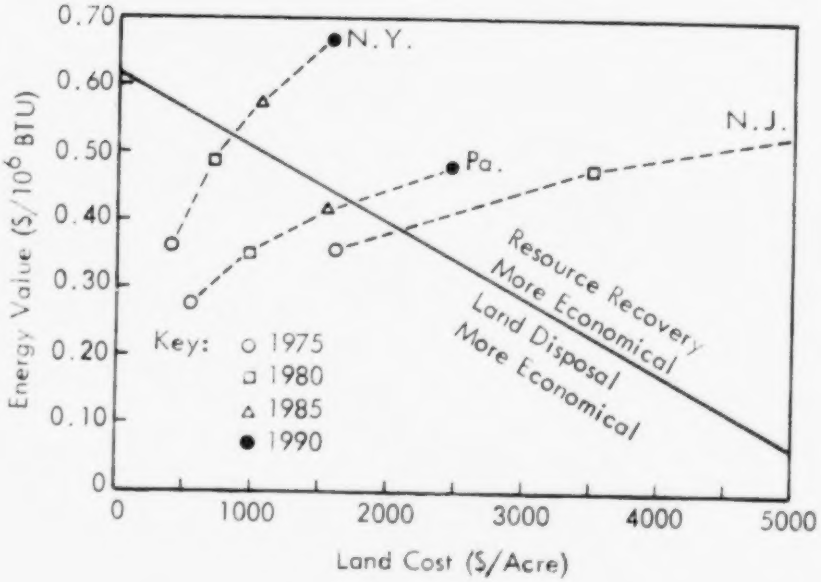


Figure 9 - Energy Values Vs. Land Cost in the Middle Atlantic States, 1972-1990

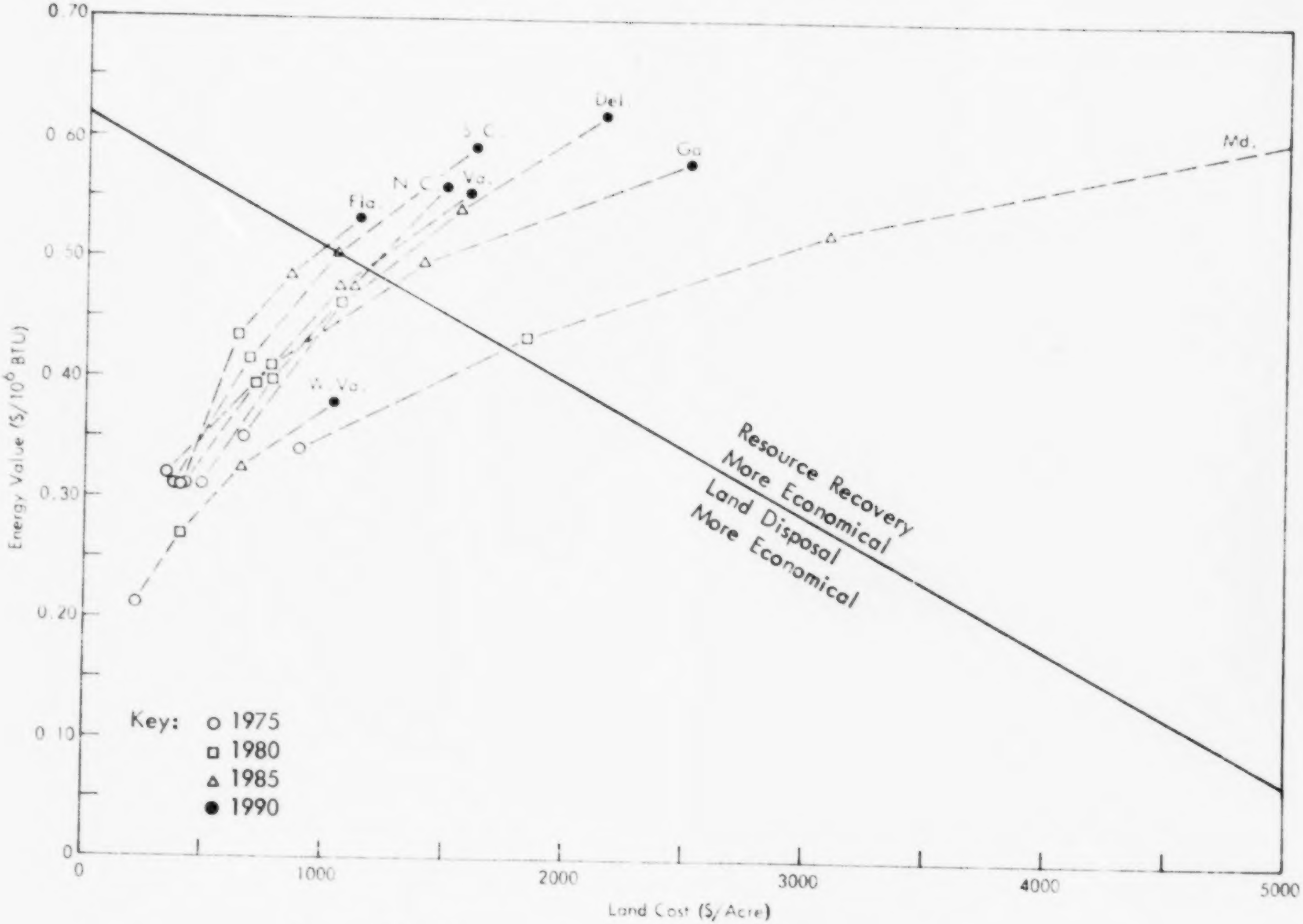


Figure 10 - Energy Values Vs. Land Cost in the South Atlantic States, 1972-1990

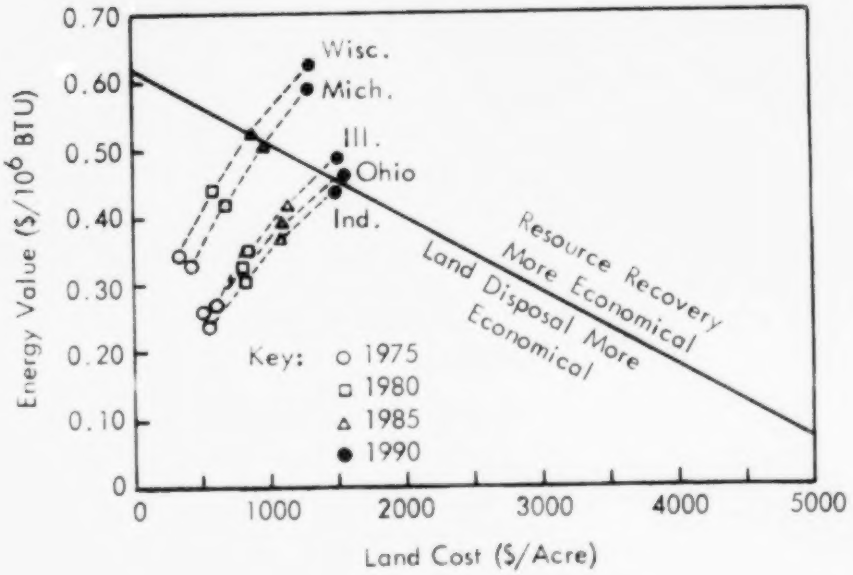


Figure 11 - Energy Value Vs. Land Cost in the East North Central States, 1972-1990

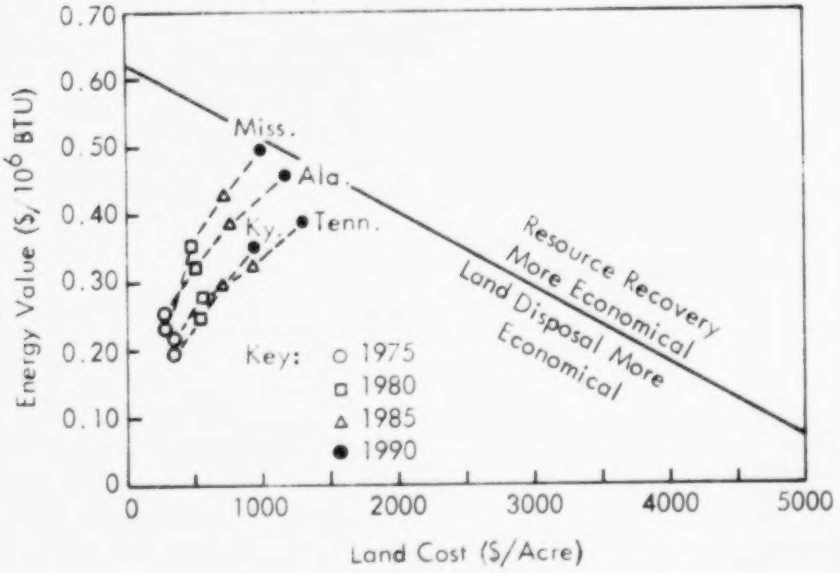


Figure 12 - Energy Value Vs. Land Cost in the East South Central States, 1972-1990

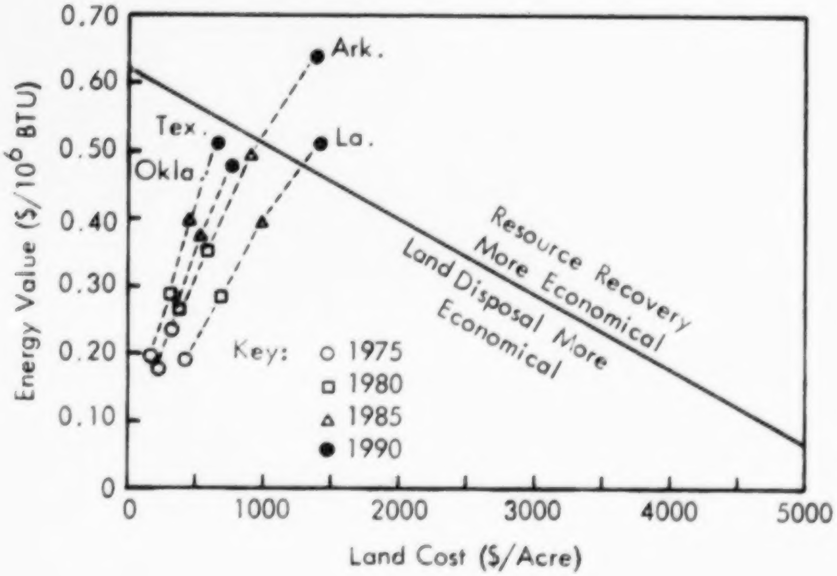


Figure 13 - Energy Values Vs. Land Cost in the West South Central States, 1972-1990

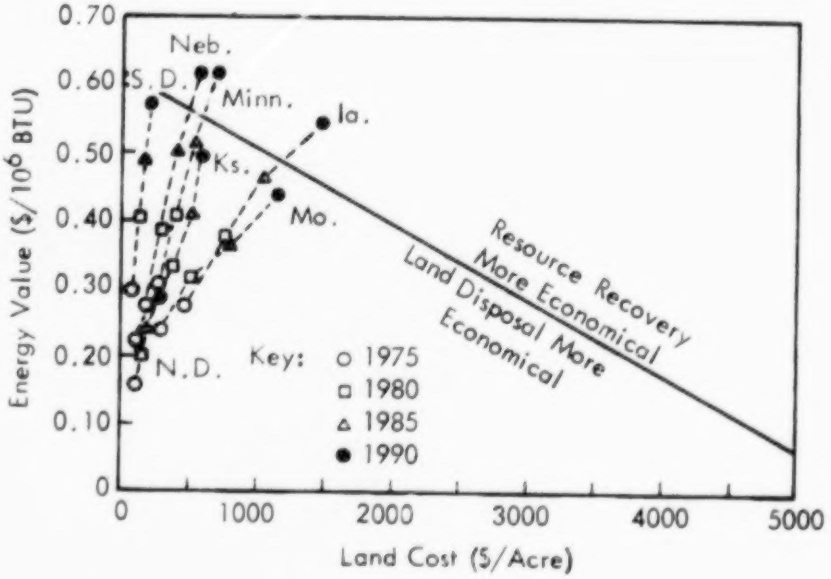


Figure 14 - Energy Values Vs. Land Cost in the West North Central States, 1972-1990

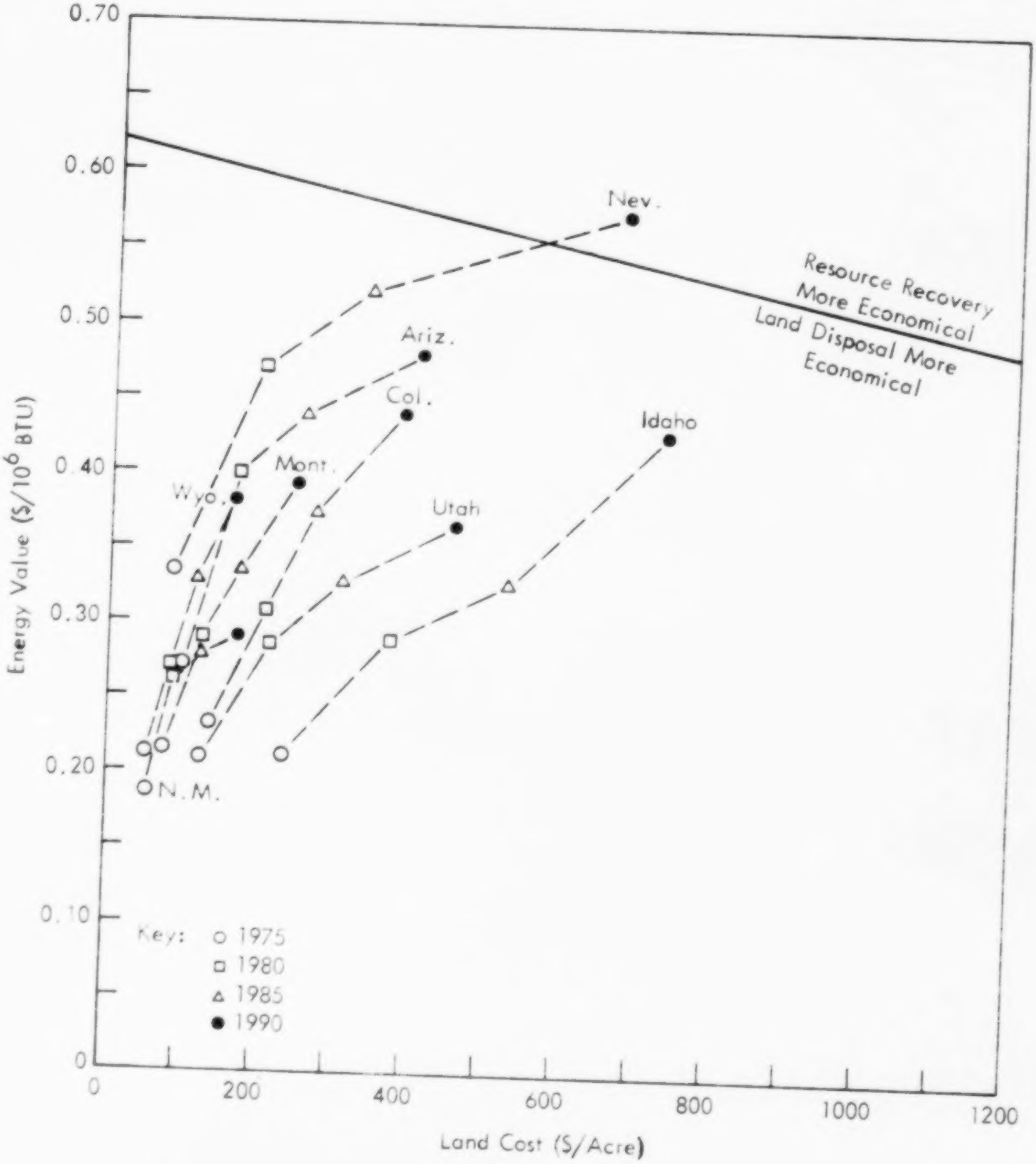


Figure 15 - Energy Values Vs. Land Cost in the Mountain States, 1972-1990

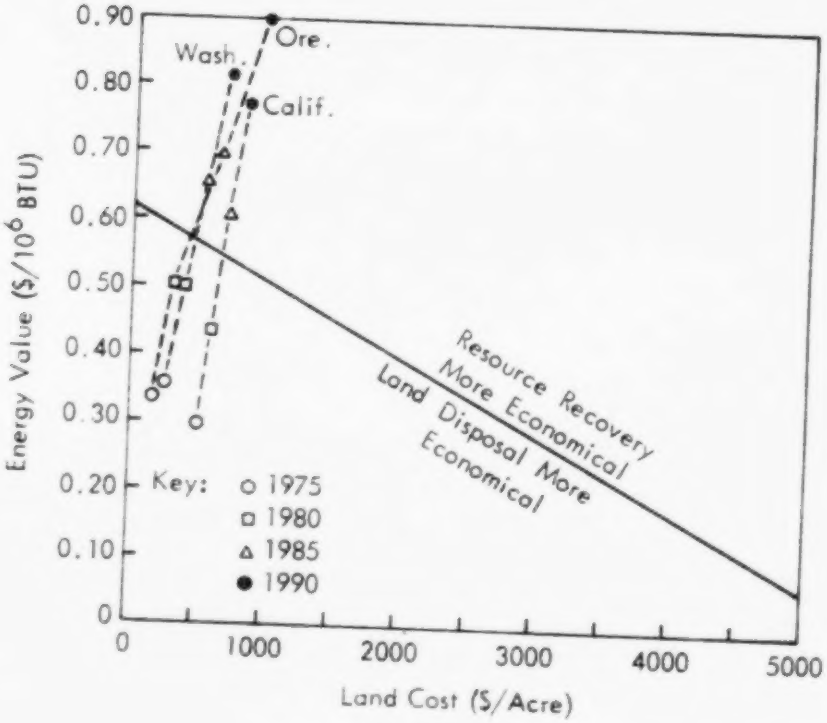


Figure 16 - Energy Values Vs. Land Cost in the Pacific States, 1972-1990

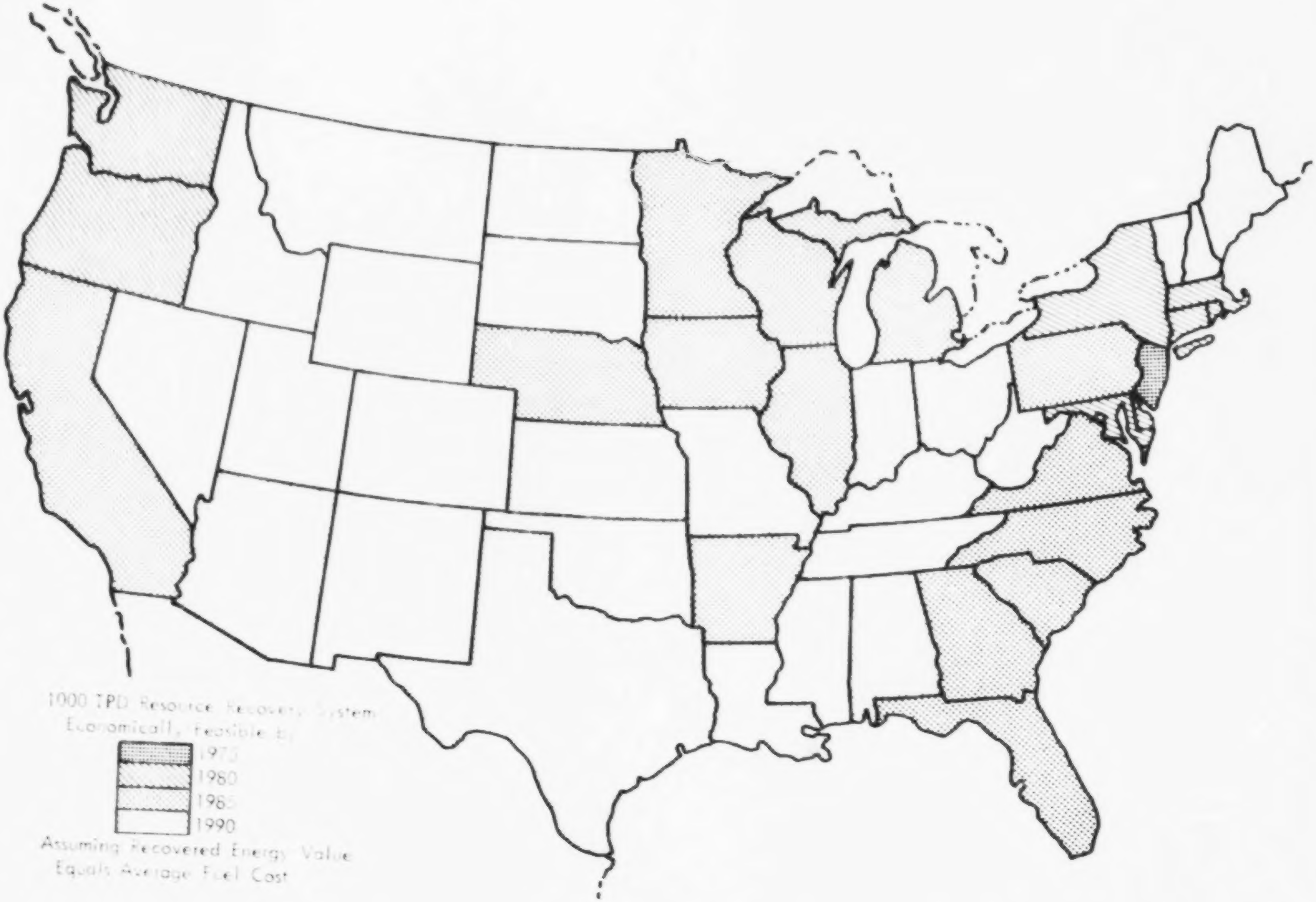
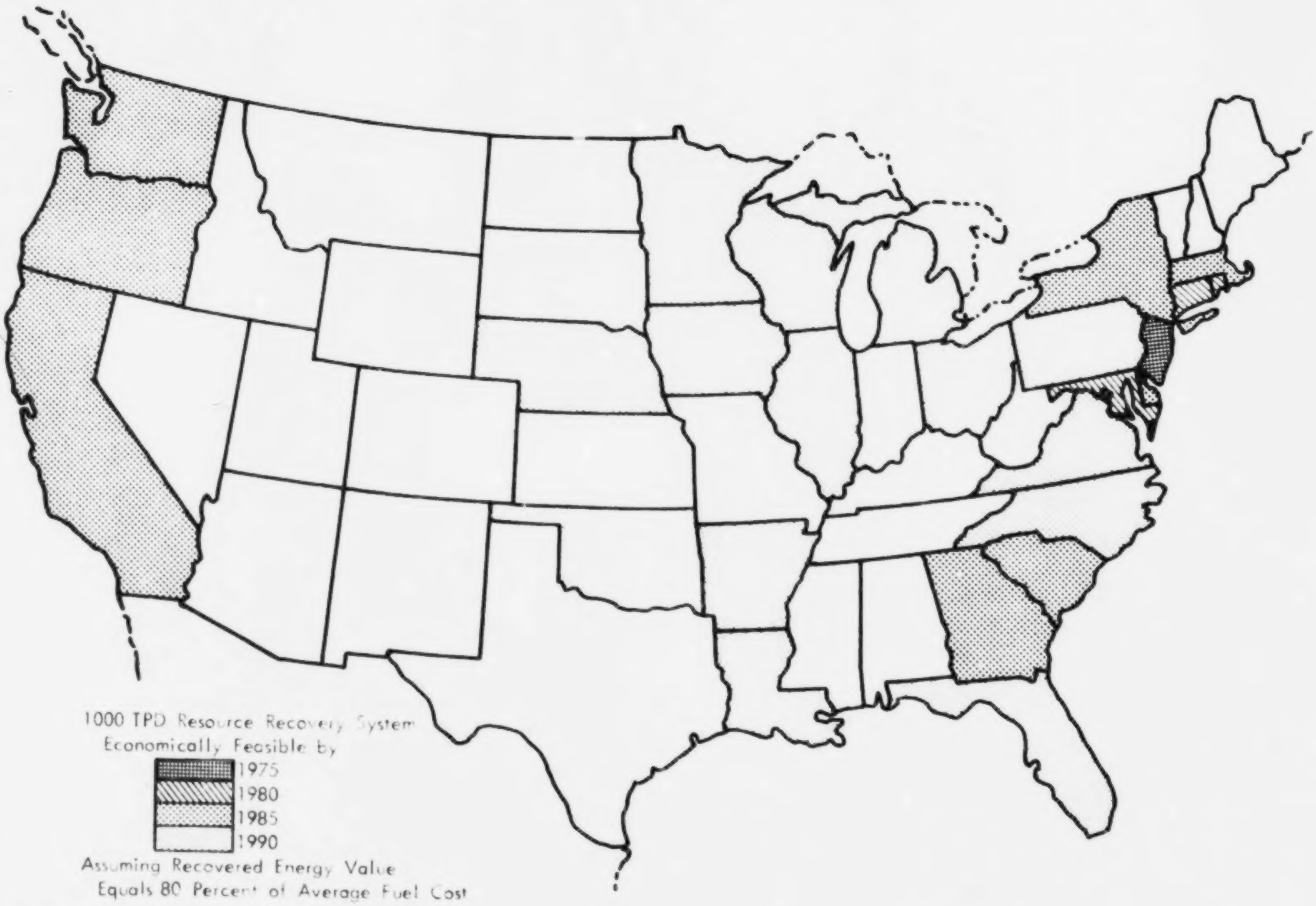

1000 TPD Resource Recovery System
Economically Feasible by
1975
1980
1985
1990
Assuming Recovered Energy Value
Equals Average Fuel Cost

Figure 17 - States Where Resource Recovery Becomes Economically Feasible, 1975-1990
(Energy Value of Waste at 100 Percent of Fossil Fuel)



1000 TPD Resource Recovery System
Economically Feasible by
▩ 1975
▨ 1980
░ 1985
☐ 1990
Assuming Recovered Energy Value
Equals 80 Percent of Average Fuel Cost

Figure 18 - States Where Resource Recovery Becomes Economically Feasible, 1975-1990
(Energy Value of Waste at 80 Percent of Fossil Fuel)

Here, it can be seen that one state (New Jersey) can justify resource recovery on purely economic grounds by 1975; resource recovery will become feasible in three more states (Rhode Island, Connecticut and Maryland) by 1980; an additional eight states will find the concept attractive by 1985; and 13 more states by 1990. Even in Washington and Oregon where hydropower is used extensively, increases in energy production will require the development of additional conventional and nuclear energy plants, with fossil fuels (chiefly coal) still expected to dominate.

Thus, by 1990, 25 states will be justified in supporting resource recovery systems on their own merits. This does not take into account the states where specific population centers may support resource recovery systems even though the statewide averages calculated here are too low to "qualify" the state itself. Thus, these calculations should be viewed as very conservative.

QUANTITY OF SOLID WASTES PROCESSED FOR RESOURCE RECOVERY

Solid Wastes Processed for Resource Recovery

The total quantity of solid wastes actually processed for resource recovery depends on a number of factors in addition to those previously discussed. Economic feasibility by itself does not, of course, mean that a project will be undertaken. New systems will be installed only when the necessity arises, and existing solid waste management plans and operations may carry many years beyond the theoretically indicated point of economic feasibility. Existing landfill sites may, for example, be entirely adequate for another 10 years or more before new disposal-planning decisions need to be made. In addition, local political and social attitudes may lead to some areas rejecting resource recovery while others will work out difficult interjurisdictional problems.

The total amount of mixed municipal solid waste generated is subject to some uncertainty. A detailed summary of solid waste generation by quantity and composition is given for the 1971 to 1990 period (Table 11). The basis of these solid waste generation values is a calculated forecast tonnage based on two key sources: EPA's estimate of mixed municipal waste generation and composition for the year 1971; and updating of this data by MRI using forecasts developed in the course of this study and other estimates.

The approach was to develop independently a material-by-material (or component-by-component) forecast of waste generation on the basis of detailed analysis in other chapters of this report. For those components of solid waste not included in this study, we made estimates of future use.

TABLE 11

MUNICIPAL SOLID WASTE GENERATED BY MATERIAL CATEGORY, 1971 TO 1990
(In Million Tons and Percent)

Waste Component	1971		1972		1975		1980		1985		1990	
	Tons	Percent	Tons	Percent	Tons	Percent	Tons	Percent	Tons	Percent	Tons	Percent
Paper	39.1	31.3	41.5	31.8	42.1	30.6	50.6	31.8	57.3	32.0	67.2	33.5
Glass - containers	11.1	8.9	12.2	9.3	13.4	9.7	15.1	9.5	15.1	8.5	15.2	7.6
other	1.0	0.8	1.0	0.8	1.1	0.8	1.3	0.8	1.5	0.8	1.7	0.8
Total Glass	12.1	9.7	13.2	10.1	14.5	10.5	16.4	10.3	16.6	9.3	16.9	8.4
Ferrous - cans and small items	8.9	7.1	9.3	7.1	9.9	7.2	11.1	7.0	12.7	7.0	13.5	6.7
bulky appliances	1.7	1.3	1.7	1.3	1.7	1.2	1.9	1.2	2.3	1.4	2.7	1.4
other	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.1
Total Ferrous	10.7	8.5	11.1	8.5	11.7	8.5	13.1	8.3	15.2	8.5	16.4	8.2
Nonferrous - packaging Al	0.6	0.5	0.7	0.5	1.0	0.7	1.3	0.8	1.8	0.9	2.0	1.0
other Al	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.1	0.2	0.3	0.2
Nonferrous - other	0.4	0.3	0.4	0.3	0.4	0.3	0.5	0.3	0.6	0.3	0.7	0.3
Total Nonferrous	1.2	1.0	1.3	1.0	1.6	1.1	2.0	1.2	2.5	1.4	3.0	1.5
Plastics	4.2	3.4	4.5	3.5	5.7	4.1	8.4	5.3	11.0	6.2	13.2	6.6
Rubber/Leather	3.3	2.6	3.4	2.6	3.7	2.7	4.3	2.7	5.0	2.8	5.8	2.9
Textiles	1.8	1.4	1.9	1.5	2.1	1.5	2.4	1.5	2.9	1.6	3.5	1.7
Wood	4.6	3.7	4.7	3.6	5.1	3.7	5.7	3.6	6.5	3.6	7.4	3.7
Sub Total - Manufactured Products	77.0	61.6	81.6	62.6	86.5	62.7	102.9	64.7	117.0	65.4	133.4	66.5
Food Wastes	22.0	17.6	22.2	17.0	23.0	16.7	24.5	15.4	26.2	14.7	27.7	13.8
Yard Wastes	24.1	19.3	24.6	18.9	26.3	19.1	29.3	18.4	32.7	18.3	36.4	18.1
Misc. Inorganics	1.9	1.5	2.0	1.5	2.1	1.5	2.5	1.6	2.9	1.6	3.3	1.6
Total Solid Waste	125.0	100.0	130.4	100.0	137.9	100.0	159.2	100.1	178.8*	100.0	200.8	100.0
Total Organics - as generated	99.1	79.3	102.8	78.9	108.0	78.3	125.2	78.6	141.6	79.2	161.2	80.3
Total Inorganics	25.9	20.7	27.6	21.1	29.9	21.7	34.0	21.5	37.2	20.8	39.6	19.7
Nominal Value	125		130		140		160		180		200	
Value at 2% compound growth	-		128		135		149		165		182	
Value at 3% compound growth	-		129		141		163		189		219	
Value at 3.5% compound growth	-		129		143		170		202		240	

Sources: "Resource Recovery and Source Reduction," Second Report to Congress, U.S. Environmental Protection Agency, 1974 p.3 (SW-[illegible]), 1971 Data; Midwest Research Institute, 1972 to 1990. See Table 11 (Continued) for the basis of the calculations.

TABLE 11 (Continued)

BASIS FOR CALCULATION OF WASTE GENERATION/COMPOSITION, 1972 to 1990

The calculation basis or data source for extending waste composition and generation was derived from each waste component as follows.

Paper: The basis was the calculated paper available in solid waste before recovery within the solid waste management system, which is the estimated actual paper discarded into solid waste systems each year (data from Table 119).

Glass: The basis was the calculated net discard for glass containers from Table 35. For noncontainer glass, we used the EPA base data for 1971 of 1.0 million tons and estimated 1.0 million tons for 1972; 1.1 for 1975; 1.3 for 1980; 1.5 for 1985; and 1.7 million tons for 1990.

Ferrous Metal: The basis was the calculated net discard for metal cans plus other ferrous metal objects in mixed waste, to which household appliance metal was added. The basis for the mixed ferrous metal is the forecast net tonnage discard each year (Table 49). Household appliance discard was based on MRI data in Table 56. A miscellaneous category for furniture, etc., was derived from EPA estimates and carried at 0.1 million tons per year to 1985, then raised to 0.2 million tons.

Nonferrous Metals: The basis for packaging metal came from Table 63. To this was added 0.1 million tons per year for nonpackaging aluminum. Also, we added 0.1 million tons for aluminum in appliances in 1972-1980; then 0.3 million tons in 1985 and 1990. The other types of nonferrous metals were based on EPA data for 1971, to which we added 0.1 million tons in 1980, 1985, and 1990.

Plastics: The basis was the net waste discard for packaging plastics plus other plastics in mixed municipal waste from Table 77. To this we added 0.2 million tons for plastics in appliances and furniture, based on the EPA data for 1971.

Rubber/Leather: The basis used was that rubber tires are 75 percent of total rubber going into municipal waste. All discarded rubber tires are shown in mixed municipal waste plus one-half of all other waste rubber products go directly into municipal waste (e.g., footwear, mechanical goods). Leather (e.g., shoes) is the balance of the tonnage in this category. We used EPA data for 1971 as the base tonnage and extended it at 3 percent growth rate to 1990.

TABLE 11 (Concluded)

Textiles: The basis used was the EPA data for 1971, extended at 3.5 percent compound growth rate to 1990.

Wood: The basis used was the EPA data for 1971, extended at 2.5 percent compound growth rate to 1990.

Food Waste Generation: The calculation basis was related directly to forecast population increase (percentage). No allowance was made for a rise or decline in the percentage of food disposal by home garbage grinding, home composting, the pattern of food consumption habits, etc. The data on population were taken from Table 21 in direct ratio to the base year of 1971.

Yard Waste Generation: The basis used was the EPA data for 1971, which was extended at an average growth rate of 2.2 percent per year, or about twice the rate of population increase. No adjustment was made for: new and total household formations; type and market share of dwelling units; air pollution regulations on open burning; home composting; size and types of yards subject to waste pickup compared to 1972. These latter factors will influence yard waste generation rates but no data were available to form a calculation basis.

Other Inorganics: The base year 1971 data are EPA's estimates which we extended at an average growth rate of 3 percent per year to 1990. This was our estimate of the overall increase in discard of unidentified inorganics--dirt, stones, brick, ceramics, various small items, etc.

The basis for our waste generation forecasts are detailed in Table 11. The actual mixed municipal waste generation will rise from 120 million tons in 1972, to 200 million tons in 1990, or a rate of increase of about 2.5 percent per year. The range of quantities in 1990 would be 180 million tons at 2 percent growth, to 240 million tons at 3.5 percent annual growth (Table 11).

In general, a metropolitan area population of more than 300,000 people is required to support a 1,000 ton per day resource recovery operation. To estimate the prevalence of resource recovery, the metropolitan areas having populations in excess of 300,000, in the states where resource recovery was believed to be economically feasible for a given year, were tabulated and the appropriate number and size of the recovery systems were estimated. It was assumed that plants would be installed initially in capacities of 1,000 to 5,000 tons per day, and that increased solid waste generation in the area could be accommodated by adding shifts or days to the plant operating schedule.

A number of different possible situations were considered, to estimate a realistic range of values. These variables included, for 1975, 1980, 1985, and 1990:

1. Three estimates of solid waste generation (low, median and high), and

2. Three estimates of the percentage of solid wastes processed for resource recovery (low, median and high).

Additionally, probabilities were assigned to each combination of variables. A probability of 0.5 was arbitrarily assigned to the median estimate in each case, and probabilities of 0.25 were given the high and low estimates. The resulting 36 outcomes (nine for each of 4 years), and their estimated probability of occurrence were tabulated, quartile ranges were defined, and the median and "most likely" estimates were identified.*

The estimated total amount of solid wastes processed for resource recovery is summarized in Table 12 for the 4 years in question, and these estimates are plotted, along with the total amount of solid waste generated, in Figure 19.

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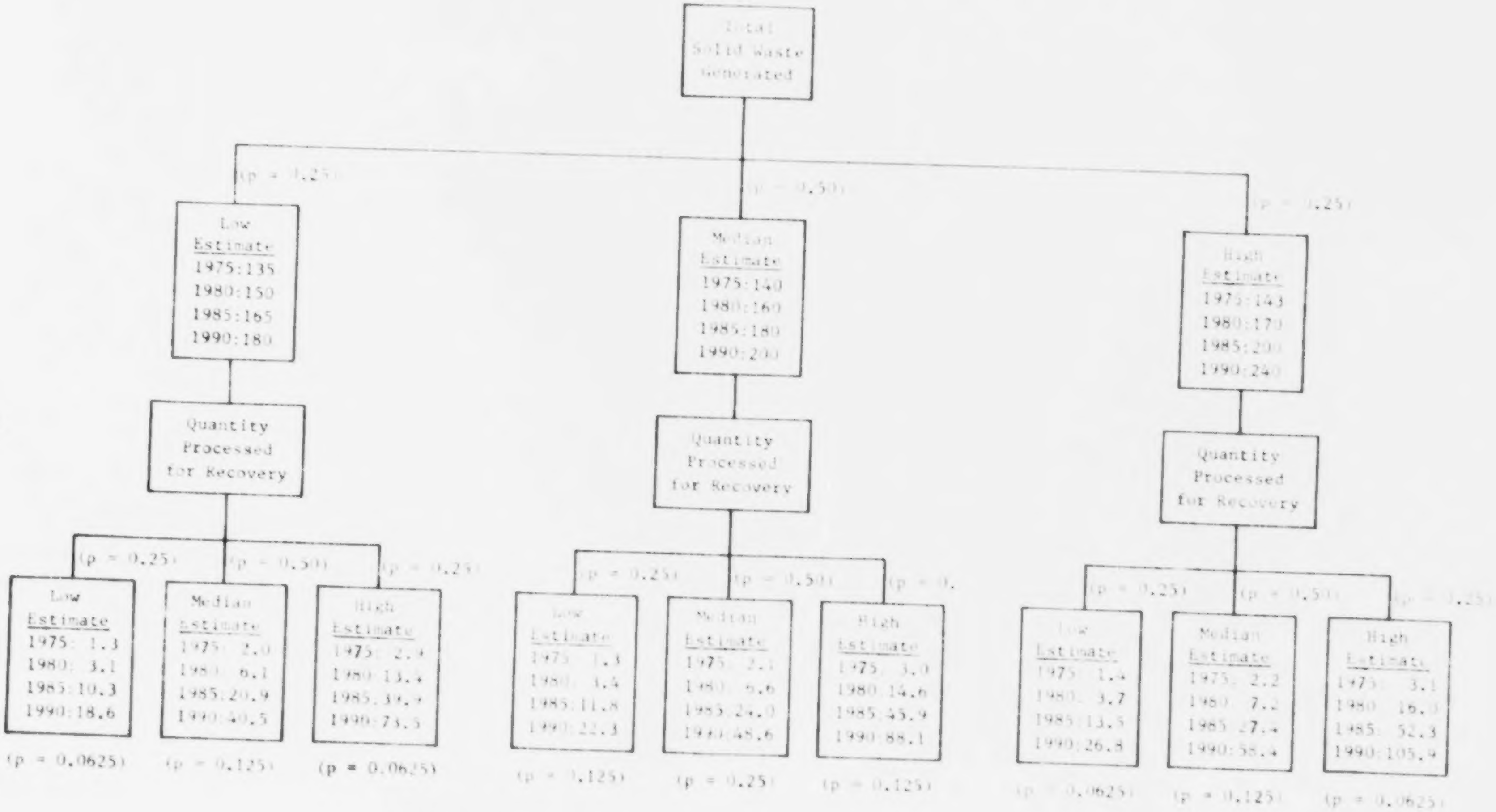
*/ This technique was used to show that there is a range of uncertainty here--the quantity of solid waste actually generated is not precisely known, and the rate at which resource recovery systems will be installed is highly uncertain.

TABLE 12

RANGE OF VALUES FOR QUANTITY OF MIXED WASTES CENTRALLY PROCESSED FOR RESOURCE RECOVERY (MILLIONS OF TONS PER YEAR)


Total
Solid Waste
Generated
(p = 0.25)
(p = 0.50)
(p = 0.25)
Low
Estimate
1975:135
1980:150
1985:165
1990:180
Median
Estimate
1975:140
1980:160
1985:180
1990:200
High
Estimate
1975:143
1980:170
1985:200
1990:240
Quantity
Processed
for Recovery
Quantity
Processed
for Recovery
Quantity
Processed
for Recovery
(p = 0.25)
(p = 0.50)
(p = 0.25)
Low
Estimate
1975: 1.3
1980: 3.1
1985:10.3
1990:18.6
(p = 0.0625)
Median
Estimate
1975: 2.0
1980: 6.1
1985:20.9
1990:40.5
(p = 0.125)
High
Estimate
1975: 2.9
1980:13.4
1985:39.9
1990:73.5
(p = 0.0625)
(p = 0.25)
(p = 0.50)
(p = 0.25)
Low
Estimate
1975: 1.3
1980: 3.4
1985:11.8
1990:22.3
(p = 0.125)
Median
Estimate
1975: 2.1
1980: 6.6
1985:24.0
1990:48.6
(p = 0.25)
High
Estimate
1975: 3.0
1980:14.6
1985:45.9
1990:88.1
(p = 0.125)
(p = 0.25)
(p = 0.50)
(p = 0.25)
Low
Estimate
1975: 1.4
1980: 3.7
1985:13.5
1990:26.8
(p = 0.0625)
Median
Estimate
1975: 2.2
1980: 7.2
1985:27.4
1990:58.4
(p = 0.125)
High
Estimate
1975: 3.1
1980: 16.0
1985: 52.3
1990:105.9
(p = 0.0625)

Source: Midwest Research Institute.

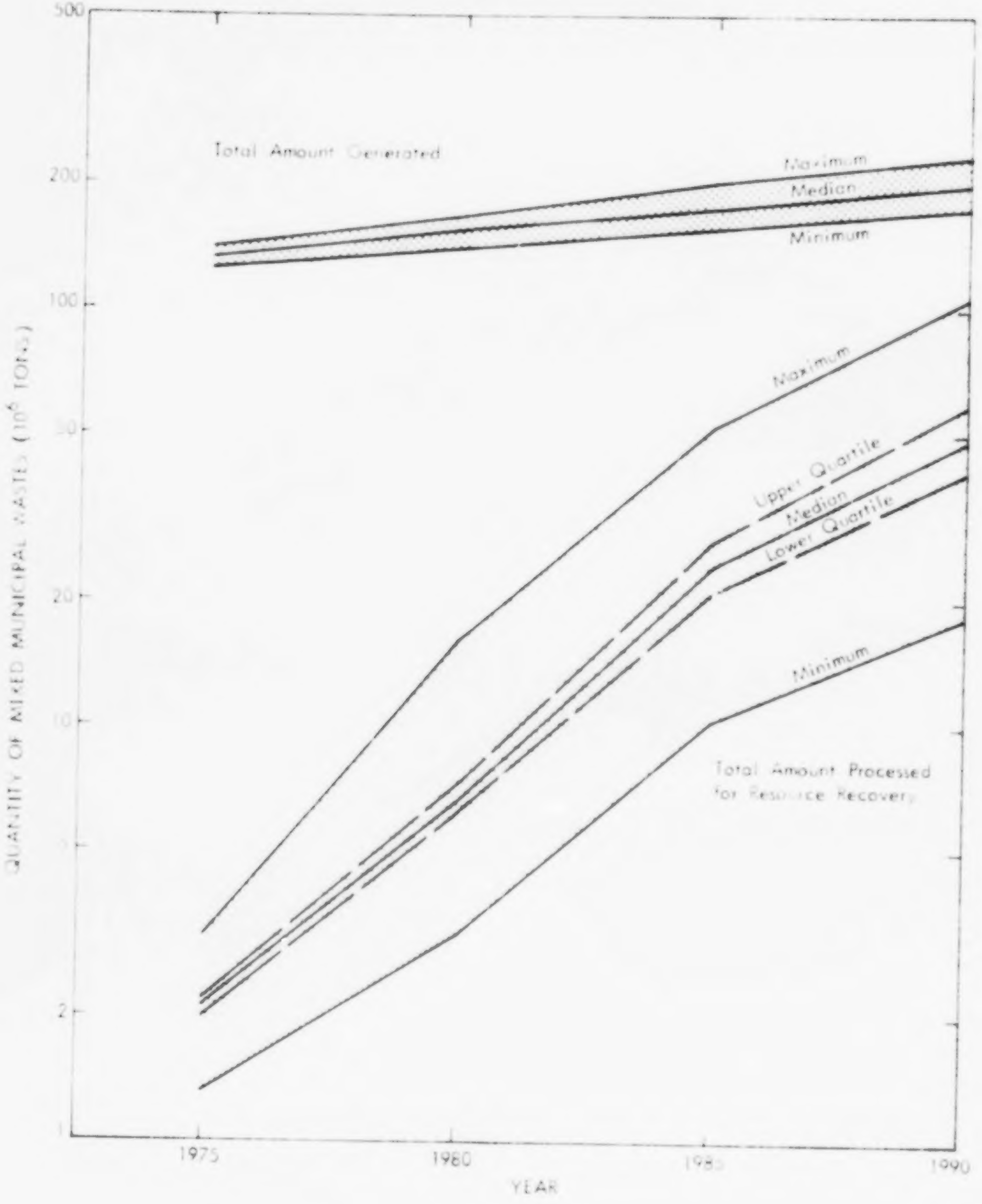


Figure 19 - Solid Waste Generation and Resource Recovery Ranges, 1975-1990

By 1990, the USA could be processing between 18.6 million tons of solid waste in centralized resource recovery systems and 105.9 million tons. This range bounds the calculated low and high estimates. The most likely resource recovery profile, i.e., the one with a probability of 0.25 of occurring, indicates that 48.6 million tons of solid waste will be processed for recovery in 1990 in centralized resource recovery facilities.

Number of Resource Recovery Systems in Operation

The quantity of solid waste processed for resource recovery (as given in the preceding section) will come principally from large municipalities in certain geographic areas. Not all areas where resource recovery is economically feasible will install systems, and not all systems that are installed will be economically feasible. The estimated number of municipalities having resource recovery systems in operation at specified points in time was estimated (Table 13). Three estimates are given for each year: a minimum, maximum, and "most likely."

TABLE 13

ESTIMATED NUMBER OF METROPOLITAN AREAS ACTUALLY HAVING RESOURCE RECOVERY FACILITIES UNDER THREE CONDITIONS, 1975 TO 1990

Year	Minimum Estimate		"Most Likely" Estimate		Maximum Estimate	
	Period	Total	Period	Total	Period	Total
1975	3	3	4	4	4	4
1980	3	6	5	9	14	18
1985	11	17	14	23	25	43
1990	8	25	17	40	22	65

Source: **Midwest Research Institute.**

The "most likely" category incorporates the calculated base estimate for total solid waste generation (Table 11); a recovered energy value of 80 percent of prevailing local fuel costs; and the "most likely" estimate for adoption of the resource recovery concept (Table 13). These are the parameters that MRI believes represent the best estimate of what will actually occur.

The resulting "most likely" estimate shown in Table 13 indicates that, by 1990, 40 metropolitan areas will have resource recovery systems in operation. (Note: We refer to metropolitan areas at this point as opposed to the total number of systems in those areas.)

The total number of recovery plants expected to be operating in these metropolitan areas were then estimated (Table 14). We estimate that five plants will be built and in operation in 1975; another seven will be installed during the 1975-1980 period; 20 between 1980 and 1985; and 28 the following 5 years. This gives a total of 60 resource recovery plants in operation by 1990, processing 48.6 million tons of mixed municipal solid wastes annually, for an average of 800,000 tons per year per plant or 2,670 tons per day per plant based on 300 days per year operation.

TABLE 14

ESTIMATED NUMBER OF RESOURCE RECOVERY PLANTS IN ACTUAL OPERATION UNDER THREE CONDITIONS, 1975 TO 1990

Year	Minimum Estimate		Most Likely Estimate		Maximum Estimate	
	Period	Total	Period	Total	Period	Total
1975	4	4	5	5	6	6
1980	4	8	7	12	15	21
1985	12	20	20	32	30	51
1990	15	35	28	60	40	91

Source: Midwest Research Institute.

The central processing plants to be actually built and on-stream in or by a given year cannot be specifically identified, but they can be expected to come principally from the metropolitan areas listed in Tables 15 and 16. It must be emphasized that resource recovery may be attractive in large metropolitan areas located in all states, because of local conditions related either to the availability and cost of landfill sites and/or conventional fuels.

The MRI estimates of the maximum number of central waste processing plants that are possible to be installed in the period 1975 to 1990 is given for the "most likely" waste generation rates and the "economically feasible" states and SMSA's for resource recovery identified in Table 15. This tabulation is a summary of the SMSA characteristics detailed in Table 15.

TABLE 15

SMSA'S OF 100,000 POPULATION OR GREATER IN STATES WHERE RESOURCE RECOVERY IS "ECONOMICALLY FEASIBLE," 1975 TO 1990

Year	State	SMSA	1970 Population (000)	Maximum Number of Feasible Central Processing Resource Recovery Plants by Size: 1,000 Tons/Day	2,000 Tons/Day	3,000 Tons/Day	4,000 Tons/Day	5,000 Tons/Day
	New Jersey	Jersey City	609		1			
		*Newark	1,857			2		
		Paterson-Clifton-Passaic	1,359				1	
		Trenton	304	1				
1980	Connecticut	*Bridgeport	389	1				
		Hartford	664		1			
		New Haven	356	1				
		Springfield-Chicopee-Holyoke	530		1			
	Maryland	*Baltimore	2,071			1	1	
		*Washington	2,861				1	1
	Rhode Island	Providence-Pawtucket-Warwick	914	1	2			
1985	Vermont	--	--					
	New Hampshire	--	--					
	Massachusetts	*Boston	2,754				1	1
		Springfield-Chicopee-Holyoke	530	1				
		Worcester	344	1				
	New York	*Albany-Schenectady-Troy	721		1			
		Binghamton	303	1				
		Buffalo	1,349				1	
		*New York	11,529			1		5
		*Rochester	883			1		
		Syracuse	636		1			
		Utica-Rome	340	1				
	Georgia	Atlanta	1,390				1	
	Delaware	Wilmington	499	1				
	Washington	Seattle-Everett	1,422					1
		Tacoma	411	1				
	Oregon	*Portland	1,009			1		
	California	Anaheim-Santa Ana-Garden Grove	1,420					1
		Bakersfield	329	1				
		Fresno	413	1				
		Los Angeles-Long Beach	7,032			1		4
		Oxnard-Ventura	376	1				
		Sacramento	801			1		
		San Bernardino-Riverside-Ontario	1,143				1	
		*San Diego	1,358				1	
		San Francisco-Oakland	3,110					2
		San Jose	1,065			1		

TABLE 15 (Concluded)

Year	State	SMSA	1970 Population (000)	Maximum Number of Feasible Central Processing Resource Recovery Plants by Size: 1,000 Tons/Day	2,000 Tons/Day	3,000 Tons/Day	4,000 Tons/Day	5,000 Tons/Day
1985	South Carolina	Charleston	304	1				
		Columbia	323	1				
		Greenville	300	1				
1990	Arkansas	Little Rock-N. Little Rock	323	1				
	Louisiana	New Orleans	1,046	1	2			
	Wisconsin	Milwaukee	1,404					1
	Michigan	*Detroit	4,200				1	2
		Flint	497	1				
		Grand Rapids	539		1			
		Lansing	378	1				
	Illinois	*Chicago	6,979			1		4
		Peoria	342	1				
	North Carolina	Charlotte	409	1				
		Greensboro-Winston-Salem-High Point	604		1			
	Ohio	*Akron	679		1			
		Canton	372	1				
		*Cleveland	2,064			1	1	
		Columbus	916			1		
		Dayton	850			1		
		Toledo	693		1			
		Youngstown-Warren	536		1			
	Nebraska	Omaha	541		1			
	Minnesota	Minneapolis-St. Paul	1,814			2		
	Iowa	Davenport-Rock Island-Moline	363	1				
	Pennsylvania	Allentown-Bethlehem-Easton	544		1			
		Harrisburg	411	1				
		Lancaster	320	1				
		*Philadelphia	4,818	1				1
		Pittsburgh	2,401				2	
		Wilkes-Barre-Hazleton	342	1				
		York	330	1				
	Virginia	Norfolk-Portsmouth	681		1			
		Richmond	518		1			
	Nevada	--	--					
	Maine	--	--					
	Florida	Fort Lauderdale-Hollywood	620		1			
		Jacksonville	529		1			
		Miami	1,268				1	
		Orlando	428	1				
		Tampa-St. Petersburg	1,013			1		

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* Resource recovery systems are currently under development in the city or SMSA.

Source: Bureau of Census 1970 Population Estimates, Midwest Research Institute.

The next calculation was an extension of the data in Table 17: the quantity of waste that would be processed if all of the systems were actually built in the years indicated and operated as given (Table 18). By 1990, it is possible that 90.9 million tons would be processed annually, or nearly half of the total waste generated. Thus, the potential for resource recovery is quite high (although our forecasts of what will actually occur are more conservative).

We have only indicated in Tables 17 and 18 the recovery processing that is economically feasible in selected states. Because of the fact that farmland values are the lowest common denominator for land disposal sites, it is to be expected that a much higher land value would be contemplated at sites closer to metropolitan areas.

Because of the fact that our land value estimates are very conservative, it is to be expected that resource recovery will be feasible in many metropolitan areas that face a waste processing decision. Thus, it follows that the plants built in any one year will not necessarily correspond to the states in which economic feasibility is demonstrated by our forecasting technique. The plants could be located anywhere the basic criteria are met. Thus, the SMSA's listed in Table 16 are also potential locations for resource recovery facilities (In fact, some already exist, e.g., St. Louis.)

Recognizing (1) that not all areas where resource recovery is economically feasible will adopt the concept; (2) that some areas will install resource recovery facilities that are not economically feasible; and (3) that many economically feasible resource recovery locations will lie outside the states identified as feasible, estimates have been made of the number and characteristics of the central processing plants that will actually be installed. The processing plant characteristics are summarized in Table 19, while the tonnages involved are presented in Table 20. (See also Tables 13 and 14 for the "most likely" columns that are the basis for the data in Tables 19 and 20.)

Thus, while we estimate that five plants will be in operation by 1975, this does not mean they will be in New Jersey, the one state that shows economic feasibility by that date. Instead, we believe the first five plants will be in St. Louis, Missouri; Chicago, Illinois; Ames, Iowa; Nashville, Tennessee; and Baltimore, Maryland. Others are being planned or have been announced.

TABLE 16

ADDITIONAL SMSA'S OF 300,000 POPULATION OR GREATER IN STATES WHERE RESOURCE RECOVERY POTENTIAL IS LIMITED*

State	SMSA	1970 Population (000)
Alabama	Birmingham	739
	Mobile	377
Arizona	Phoenix	968
	Tucson	352
Colorado	Denver	1,228
Indiana	Gary-Hammond-E. Chicago	633
	Indianapolis	1,110
Kansas	Wichita	389
Kentucky	Louisville	827
Louisiana	New Orleans	1,046
Missouri	Kansas City	1,254
	**St. Louis	2,363
New Mexico	Albuquerque	316
Oklahoma	Oklahoma City	641
	Tulsa	477
Tennessee	Chattanooga	305
	**Knoxville	400
	**Memphis	770
	**Nashville	541
Texas	Beaumont-Port Arthur-Orange	316
	Dallas	1,556
	El Paso	359
	Ft. Worth	762
	Houston	1,985
	*San Antonio	864
Utah	Salt Lake City	558

** Resource Recovery Systems are currently under development or active consideration.

* These are states not included in Figure 18 for statewide economic feasibility for resource recovery.

Source: Midwest Research Institite.

TABLE 17

CHARACTERISTICS OF CENTRAL PROCESSING PLANTS IN STATES AND SMSA's WHERE RESOURCE RECOVERY IS ECONOMICALLY FEASIBLE[a]

Year	No. of States	No. of SMSA's	No. of Central Processing Plants by Size: 1,000 Tons/Day	2,000 Tons/Day	3,000 Tons/Day	4,000 Tons/Day	5,000 Tons/Day	Total Plants
1975	1	4	1	1	2	1	0	5
1980	3	7	2	2	4	2	1	11
1985	10	28	12	2	6	5	14	39
1990	15	35	13	11	10	5	10	49
Total	29	74	28	16	22	13	25	104

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[a] Assumes "most likely" parameters and includes only SMSA's of 300,000 people or more in states where resource recovery becomes economically feasible (Table 15 and excludes SMSA's in Table 16).

Source: Midwest Research Institute.

TABLE 18

WASTE PROCESSING POTENTIAL IN STATES WHERE RESOURCE RECOVERY IS ECONOMICALLY FEASIBLE[a]

Year	Quantity of Waste Throughput in Central Processing Plants by Size (Tons/Year): 1,000 Tons/Day	2,000 Tons/Day	3,000 Tons/Day	4,000 Tons/Day	5,000 Tons/Day	Total
1975	300,000	600,000	1,800,000	1,200,000	0	3,900,000
1980	600,000	1,200,000	3,600,000	2,400,000	1,500,000	9,300,000
1985	3,600,000	1,200,000	5,400,000	6,000,000	21,000,000	37,200,000
1990	3,900,000	6,600,000	9,000,000	6,000,000	15,000,000	40,500,000
Total	8,400,000	9,600,000	19,800,000	15,600,000	37,500,000	90,900,000

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[a] Assumes "most likely" parameters and includes only SMSA's of 300,000 people or more in states where resource recovery becomes economically feasible (Table 15).

Source: Midwest Research Institute, based on Table 17.

TABLE 19

CHARACTERISTICS OF CENTRAL PROCESSING PLANTS, NEWLY INSTALLED, 1975-1990[a]

Year	No. of SMSAs	No. of Plants by Size: 1,000 Tons/Day	2,000 Tons/Day	3,000 Tons/Day	4,000 Tons/Day	5,000 Tons/Day	Total No. of Plants
1975	4	3	2	0	0	0	5
1980	5	2	2	3	0	0	7
1985	14	6	2	5	2	5	20
1990	17	7	5	6	3	7	28
Total	40	18	11	14	5	12	60

Source: Midwest Research Institute.

[a] Includes plants in SMSA's both in and outside of states in which resource recovery will become economically feasible by 1990 (Tables 15 and 16).

TABLE 20

TOTAL MIXED SOLID WASTE CENTRALLY PROCESSED FOR RESOURCE RECOVERY, BY YEAR, 1975 TO 1990

(In thousand tons)

Year	Plants Installed	Total Plants In Use	Quantity of Waste Processed[a]: Year	Total
1975	5	5	2,100	2,100
1980	7	12	4,500	6,600
1985	20	32	17,400	24,000
1990	28	60	24,600	48,600

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[a] Based on "most likely" estimated number of plants, operating at daily capacity 300 days per year (Table 19).

Source: Midwest Research Institute.

By 1990, we believe the geographic pattern of plant installation will conform more closely to the forecast model we have used, if some allowance is made for "exception" metropolitan areas in states that do not become "eligible for resource recovery under our base criteria." Local conditions, including the economic, political and social climate of an area, will lead to some deviations from our general model, and this is fully recognized as a factor. For example, St. Louis, Missouri, and Nashville, Tennessee, are already well along in the development of recovery facilities. Thus, other sites may develop recovery systems, even if the state itself does not meet the base criteria of our forecast.

CHAPTER IV

GENERAL APPROACH AND METHODOLOGY FOR ANALYSIS OF SEVEN MATERIALS IN SOLID WASTES

INTRODUCTION

Much of the detail of this report is devoted to development of forecasts of recovery for the major materials included in the study. In three of these materials, there is significant recycling now from post-consumer waste--ferrous metals, aluminum, and paper. In two, there is limited recycling of post-consumer waste--glass and rubber. Plastics recovery (post-consumer waste) for recycling is not practiced in significant quantity.

Each of the materials is covered in a separate chapter following this one. The objective of each material discussion is to arrive at a forecast of resource recovery for the 1972 to 1990 period for that material, focusing on recovery from the solid waste stream.

GENERAL METHODOLOGY AND APPROACH

The forecasts of resource recovery have been developed using a common methodology and sequence of analysis tasks for each material.

First, a forecast of material demand and production was made to 1990 for the industry in question, e.g., paper. This included the details of selected segments of the industry that were of particular interest in this study such as packaging uses. In effect this was a market analysis and forecast, which established the basis on which solid waste and resource recovery profiles could be developed. (The specific products detailed for each material are given in the chapters, e.g., glass containers.)

Second, we developed a profile of waste generation for each material based on demand and the use characteristics of the end products. There was a time element assigned to waste generation rates based on the product life cycle. For example, newspapers and most packaging become waste almost as produced, i.e., on a very short life cycle. Other items such as appliances may not appear in the waste stream for years. These factors were taken into account. In addition, products that are unrecoverable or fail to enter into the municipal waste stream were accounted for, including uses in which a product leaves the municipal waste cycle or is unidentifiable again, e.g., roofing felts (which come into demolition wastes) or auto panel hard-board (which is part of auto hulks); or toilet paper which is disposed of in sewage systems. The result of this step was the development of a waste profile based on: product life cycle; disappearance or diversion from municipal waste; and time/rate of generation. We determined only net waste generation, i.e., that withdrawn from the waste stream for recycling is not shown as waste material handled within solid waste systems for disposal.

Third, the municipal waste generation was determined by source: residential, commercial/institutional, and industrial. For the most part, we determined this by judgment and selected reference to published data. Most products are household waste because so much of the study emphasis was on packaging and other consumer products. However, an allocation was made to each source.

Fourth, we determined what portion of the waste generated is potentially recoverable for recycling, reuse or useful conversion. Our basic premise was that any waste in an SMSA was "accessible" to recovery from an economic, geographic, and quantity standpoint. In general, about 70 percent of waste generated falls in this category. Over and above that allowance must be made for actual collection and mechanical efficiency if recovery is to be realistically assessed. A broad generalization is that 70 percent efficiency is realistic, which means that from a recovery potential standpoint, about 50 percent of waste generated nationally could be recovered (0.70 of quantity x 0.70 efficiency).

Fifth, we made a forecast of actual resource recovery based upon our best estimates of the recycling requirements of the various industries and the extent to which waste recovery options would provide the material from municipal waste. The recovery modes included "traditional" secondary materials recovery procedures; source separation; consumer collection centers; transfer station separation; and centralized waste processing facilities. The recovery profile forecast for each material was developed to 1990, including the quantity recovered for its energy content.

In the case of the materials chapters that follow, only the "most likely" recovery forecasts are included. However, as indicated in Chapter III, we did make an estimate of the range over which resource recovery could apply from 1975 to 1990. The recovery profile for each material would vary proportionately to that range, which is based upon solid waste processed through resource recovery systems.

Finally, incorporated within each of these material and recovery forecasts are the effects of some variables that could influence the recovery profiles (upward or downward). The consideration of special factors is a part of any forecast and these considerations were incorporated implicitly or explicitly. Specific factors that were considered included: demand for products compared to natural resource availability or resources; end use trends in various markets; environmental standards; trends in energy availability; waste disposal and processing cost trends; public attitudes toward resource use, recycling and solid waste. An example of an assumption is that state legislation on beverage containers (e.g., Oregon, Vermont) would extend to five or six states in the future. We believe they would be low population areas and the effect of state legislation on the total demand forecasts would be minimal even though laws may eliminate all but returnable containers in those few states.

By contrast, if we have missed the intermaterials competition effects or the impact of the energy crisis, our forecasts of demand for materials could be high, and for any material (e.g., aluminum, plastics) could differ considerably from what we forecast. Likewise, the resource recovery pattern could differ considerably as well, if major developments override our basic judgments for each material. However, we point these factors out only to call attention to the fact that any forecast must be considered in the light of the conditions on which it is based. We believe that the forecasts developed in this report are a realistic assessment of the future.

BASIC ECONOMIC AND POPULATION DATA

The demand and use of products commonly relates to such basic factors as "real" GNP, disposable income, population and other economic indicators. The basic data used in this report as background for some of the forecasts of demand and recovery is given in Table 21. These basic economic data were derived from various sources (government, industry, private) and are not MRI forecasts. However, the forecasts in the other chapters of the report utilize this information where appropriate to develop our own forecasts.

The chapters which follow detail the materials individually. The following three cover the inorganics--glass, ferrous metals, and aluminum. The subsequent three cover the organics--plastics, rubber and paper.

GENERAL OBSERVATIONS ON MATERIALS RECOVERY

The materials included in this study will be utilized in two recovery options in the future--recycling or energy recovery. The inorganics are suited best for recycling applications--ferrous metals, aluminum and glass. Of these, ferrous metals and aluminum should have little problem being recycled

TABLE [illegible]

BASIC ECONOMIC INDICATORS, 1960-1990

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
GNP (Billion Real Dollars)a/	683.8	696.1	719.3	746.8	786.0	835.0	887.0	914.2	957.0	980.4	974.1
GNP (Billion Current Dollars)	503.7	520.1	560.3	590.5	632.3	684.9	749.9	793.9	864.2	929.1	974.1
Per Capita Income (Real) a/	2,437.0	2,472.0	2,549.0	2,609.0	2,753.0	2,899.0	3,024.0	3,111.0	3,219.0	3,281.0	3,358.0
Population (In millions)	180.7	183.6	186.5	189.1	191.8	194.2	196.4	198.6	200.6	202.5	204.8
Disposable Personal Income Billion (Real) Dollarsa/	440.7	453.8	475.1	493.4	527.9	562.9	593.9	617.9	645.7	664.5	687.8

	1971	1972	1973	1975	1980	1985	1990
GNP (Billion Real Dollars)a/	998.7	1,055.0	1,111.0	1,209.0	1,474.0	1,764.0	2,054.0
GNP (Billion Current Dollars)	1,046.8	1,147.0	1,248.0	1,427.0	1,970.0	2,685.0	3,285.0
Per Capita Income (Real)a/	3,442.0	3,500.0	3,701.0	3,806.0	4,288.0	4,750.0	5,171.0
Population (In millions)	207.0	209.0	211.5	216.5	230.8	246.2	260.7
Disposable Personal Income Billion (Real Dollars)a/	712.5	534.0	785.0	830.0	1,015.0	1,225.0	1,440.0

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a/ Base Year 1957.

Sources: Bureau of the Census, Series P-25, No 476, February 1972, Projection Series D
Predicasts, Inc., Issue No. 48, July 28, 1972.

in whatever quantity they can be recovered. Both can be recovered in centralized processing facilities or in collection/separation centers. However, the technology of aluminum recovery has not yet been demonstrated on a commercial basis. The recipient industries (steel and aluminum) will be capable of accommodating increased recycling, and will very likely encourage it.

Glass recycling will depend heavily on locational factors and the technological capability to produce color sorted materials. Since the basic raw materials for glass are in adequate supply, the technology of recovery is unproven, and container plants are not near every large population center, the recycling of glass will not move ahead as rapidly as will the other inorganic materials (metals).

Of the organics, recycling appears to be viable only for paper. Paper can best be recovered for recycling via source separation, and by collection within solid waste management systems. However, some paper will also be recovered for recycling from centralized recovery facilities. That which cannot be recovered for recycling can be processed for its energy content.

The other organic materials in mixed waste are suitable for energy recovery options of various kinds. Most plastics, textiles and rubber are derived from hydrocarbon sources giving them a high energy content per pound. In addition, there are difficulties in recycling plastics, rubber and synthetic textiles, although rubber tires could enter a reuse mode if retreading returns to favor for private automobiles.

The greatest uncertainty in the MRI forecasts is the effect that energy conservation practices will have on recycling and resource recovery. Energy conservation practices directed at fossil fuels could have several effects as they relate to our specific recovery forecasts for each material: (1) Reduce the total demand for some materials: (2) Shift demand to less energy intensive products--in which case plastics, synthetic textiles, and aluminum would not reach the demand levels we forecast; (3) Stimulate recycling/reuse because of internal industry process energy savings for some materials; and (4) Stimulate energy recovery via substitution of solid waste for fossil fuels in power generation and industrial processes. It is likely that all four of these factors will occur to some extent.

Of these, we believe that the current energy supply shortage in the U.S.A. will tend to stimulate recycling and reuse and lead to more rapid development of energy recovery from solid waste. Thus, if anything, our resource recovery forecasts could prove to be conservative.

CHAPTER V

RECOVERY FORECASTS FOR GLASS CONTAINERS TO 1990

SUMMARY

The demand for all glass containers will increase at the rate of 2.6 percent per year between 1972 and 1980, after which time, total demand will essentially level out to 1990. The growth of the nonreturnable beverage container is nearing full maturity. Therefore, growth in this product group will slow. Glass will lose market share to plastic and metal containers.

The total tonnage of glass container waste generated will rise from 12.2 million tons in 1972, to 15.1 million tons in 1980, and 15.2 million tons in 1990. This is equivalent to 38.7 billion units in 1972 and 43.3 billion units in 1980. Of the total tonnage, 8.4 million tons were generated in SMSA's in 1972, 10.7 million tons in 1980, and 11.[illegible] million tons will be generated in SMSA's in 1990.

On a source basis (1972) about 10 million tons or 82 percent of waste glass containers are generated in households; 2 million tons are generated in commercial and institutional establishments, and 0.2 million tons are generated in industrial plants. This relationship will not change significantly over time.

Other glass waste amounting to 1.0 million tons in 1972 brought total glass in municipal solid waste to 13.2 million tons in 1972; by 1990, other glass waste will be 1.7 million tons and total glass waste 16.9 million tons. Noncontainer glass consists of window glass, drinking ware and miscellaneous uses of glass, e.g., laboratory glass.

We estimate that only SMSA's have the population base and density to sustain significant glass recovery operations. Recycling of glass back into containers will be the most predominant use of recovered glass. However, several factors lead us to conclude that the recovery of glass containers from waste will be modest and develop slowly. These are: the technology and economics of glass recovery from mixed municipal waste are still experimental; the logistics of transportation will influence recovery since many SMSA's are remote from glass container plants; there is an abundance of soda ash and sand, the basic raw materials; the specifications for color sorted cullet are likely to be difficult to achieve; the mechanical efficiency of recovery technology is relatively low at present.

Nevertheless, we believe glass container cullet will be recovered via three mechanisms: voluntary citizen collection; commercial cullet dealers; glass recovery processing systems associated with mixed waste processing for resource recovery. Of these, voluntary collections will become somewhat more important; cullet dealer operations will all but disappear; and recovery of glass from central processing systems will begin about 1980.

The MRI forecasts of recovery are summarized for the 1972 to 1990 period in Table 22. Total recovery for recycling will rise from 275,000 tons in 1972 to 850,000 tons in 1990.

The recovery of waste glass (principally containers) for recycling will rise from 275,000 tons in 1972 to 850,000 tons in 1990; or from 3.3 percent to 7.7 percent of total waste glass generation. After 1980, the primary recovery technique will be mechanical separation of glass from mixed waste in association with large centralized recovery operations. Most of the glass recovered will be recycled into containers although a small amount will be utilized in other products such as glass wool and terrazzo tile.

INTRODUCTION

Glass containers are one of the oldest packages for containing liquids and solids. Glass is nonporous, transparent, chemically inert, impermeable to oxygen and carbon dioxide and can be cast and shaped into many forms and sizes. Because it is impermeable, it does not retain odors and can be cleaned and reused. These properties have made it a desirable container for packaging a wide variety of foods and beverages such as soft drinks, beer, wine and distilled spirits. Drugs, pharmaceuticals, toiletries, and cosmetic products are also packaged in glass containers, along with numerous household and industrial chemical items. These uses represented a market for 38.7 billion new containers in 1972.

It is estimated that refillable glass containers for soft drinks, beer and milk were filled 32.4 billion times during 1972, bringing the total to 71.1 billion containers shipped to the marketplace during the year.

TABLE 22

SUMMARY OF WASTE GLASS RECOVERY, 1972 TO 1990
(In Thousand Tons)

Year	Total Glass Waste Generated	Glass Container	Amount Processed for Recovery[a]	Amount Recovered Mechanical System[b]	Amount Recovered via Separate Collection[c]	Total Recovery	Percent Recovery
1972	13,200	12,220	0	0	275	275	2.8
1975	14,500	13,440	20	10	265	275	1.8
1980	16,400	15,110	170	100	275	375	2.3
1985	16,600	15,110	540	350	250	600	3.6
1990	16,900	15,200	860	600	250	850	5.0

Source: Midwest Research Institute.

[a] Only that which is processed in a glass recovery subsystem, the total glass in waste processed will be higher (see Table 4).

[b] About 90 percent of the glass is container glass.

[c] Nearly all of this is considered to be container glass.

GLASS CONTAINER DEMAND BY MARKET, 1962 TO 1990

Trends in Container Demand

Glass container demand increased at 4.4 percent per year, from 1962 to 1972, or from 25.05 billion units to the present level of 38.7 billion units (Table 23). This growth was quite smooth during the first half of the decade but has been erratic in recent years partly as a result of the effects of a strike in 1968 and of changing patterns in the soft drink markets. Glass containers accounted for 6.75 million tons of material in 1962 and had nearly doubled by 1972 to 12.22 million tons for a growth rate of 6.1 percent per year. By 1980 it appears that glass container demand will have reached full maturity at 43.4 billion units and 15.1 million tons.

Nonreturnable soft drink and beer containers were responsible for almost all of the 13.6 billion increase in glass container demand between 1962 and 1972 (Table 24). Nonreturnable soft drink containers account for 61 percent of this total as they increased from 480 million to 8.76 billion during this period. Almost all of the growth occurred between 1965 and 1970, when the single-trip container became a commercially accepted product. Since 1970, growth in total volume packaged has slowed considerably as the markets for glass one-trip containers approach saturation. Unit growth has slowed more as the 32-ounce and larger containers replace smaller sizes.

TABLE 24

NET CHANGE IN GLASS CONTAINER SHIPMENTS, 1962 TO 1980
(In billion containers)

Container Type	Period 1962-1972	Period 1972-1980
Soft Drink (returnable)	(0.15)	(0.15)
Soft Drink (nonreturnable)	8.28	2.44
Beer (returnable)	(0.10)	(0.03)
Beer (nonreturnable)	4.17	1.51
Liquor	0.68	0.56
Wine	0.62	0.43
Food	1.85	0.48
Medicine and Health	(0.28)	(0.24)
Toiletries and Cosmetics	(0.71)	(0.34)
Household and Chemical	(0.75)	(0.11)
Total	13.61	4.75

Source: 1962-1972, U.S. Department of Commerce; 1962-1972, Liquor and Wine - MRI estimate; 1972-1980, MRI estimate.

TABLE 23

GLASS CONTAINER DEMAND BY UNITS AND TONNAGE, 1962-1990

	1962		1972		1975		1980		1990	
	Units Billion[a]	Tons (000)[c]	Units Billion[a]	Tons (000)[c]	Units Billion[a]	Tons (000)[c]	Units Billion[a]	Tons (000)[c]	Units Billion[a]	Tons (000)[c]
Soft Drink - Returnable	1.60	774.9	1.45	802.9	1.30	772	1.30	722	1.30	722
Soft Drink - Nonreturnable	0.48	177.4	8.76	3,315.7	9.90	3,953	11.20	4,666	11.20	4,666
Beer - Returnable	0.35	121.4	0.25	75.8	0.22	70	0.22	72	0.22	72
Beer - Nonreturnable	3.42	784.0	7.59	1,815.7	8.28	2,070	9.10	2,338	9.10	2,338
Liquor[b]	1.72	737.0	2.40	1,120.8	2.66	1,293	3.16	1,591	3.16	1,591
Wine[b]	0.75	373.9	1.37	828.2	1.53	983	1.80	1,218	2.10	1,421
Food	10.07	2,313.3	11.92	3,017.7	12.21	3,180	12.40	3,358	12.40	3,358
Drug and Pharmaceutical	3.25	745.4	2.97	755.0	2.88	750	2.73	739	2.60	704
Toiletries and Cosmetics	2.05	467.0	1.34	333.8	1.12	292	1.00	271	0.70	190
Household and Chemical	1.36	313.8	0.61	154.0	0.50	130	0.50	135	0.53	143
Total Domestic	25.05	6,749.1	38.66	12,219.6	40.60	13,443	43.41	15,110	43.31	15,205
Export	0.28		0.25		0.25		0.25		0.25	
Total	25.33		38.91		40.85		43.66		43.56	

		Units	Tons
Growth rate %/year	1962-1972	4.4	6.1
	1972-1980	1.5	2.6
	1980-1990	0	0

Source: a/ U.S. Department of Commerce, 1962-1972.

b/ Domestic production for U.S. imports.

c/ Midwest Research Institute estimates based upon average weights reported by Glass Container Manufacturers Institute, Midwest Research Institute estimates, 1975-1990.

The acceptance of the single-trip beer bottle began much earlier and demand increased from 3.42 billion containers in 1962 to 7.59 billion in 1972. This 4.17 billion unit increase accounted for 31 percent of the total increase in demand for glass containers. Growth was steady during the early part of the decade, but has slowed since 1970 as the potential for replacement of the round-trip container reaches completion. It is not difficult to see why glass container manufacturers have pursued the non-returnable beer and soft drink markets--all of the other end uses grew modestly or declined in the 1962 to 1972 period as plastics, steel and aluminum packages displaced some user of glass.

Food, liquor, and wine containers increased modestly during the period. Food is a very stable but large market for glass containers. Container use increased from 10.07 billion in 1962 to 11.92 billion in 1972, which is about equivalent to population growth. Increasing personal disposable income has stimulated the growth for wine and liquor as container use increased from 2.47 billion units in 1962 to 3.77 billion in 1972.

All other uses declined during this period. Returnable beer and soft drink containers were replaced by the one-trip glass container and metal can. The use of plastic and metal containers (including aerosols) have caused a decline in household and industrial chemical, toiletry and cosmetic, and drug and pharmaceutical containers. Demand for glass containers in these markets has decreased 26.2 percent from 6.67 billion containers in 1962 to 4.92 billion in 1972.

The future markets for glass containers will be similar to past markets with nonreturnable soft drink and beer containers accounting for most of the growth. However, this growth will be at a much slower rate because the substitution for the returnable container is reaching its maximum market penetration. Further, the trend to large sized soft drink containers, coupled with a slowing of soft drink demand, will reduce the need for additional new containers.

One-way beer containers will increase from 7.59 billion in 1972 to 9.10 billion in 1980, at which time we expect demand to level out. Correspondingly, one-way soft drink containers will increase from 8.76 billion to 11.20 billion during the same period. Beyond 1980, the all-plastic beverage container will become commercial and will capture most, if not all, of the growth that would have gone to glass containers. Demand in 1990 will be at the same level as 1980.

Glass, food, liquor and wine containers will increase slowly, but plastic containers will capture more of the food market. Food containers will increase from 11.92 billion in 1972 to 12.40 billion in 1980. Liquor and wine will grow at a faster rate as the population shifts to a greater percentage in the "drinking age." Demand will increase from 3.77 billion containers in 1972 to 4.96 billion in 1980.

Returnable beer and soft drink containers should end their decline by 1975, as the one-way container approaches its maximum market share. Demand in 1980 will be 1.52 billion containers.

Household and industrial chemicals, toiletry and cosmetics, and drug and pharmaceutical containers will continue to decline from 4.92 billion in 1972 to 4.23 billion in 1980, as plastic containers continue to capture markets as the result of the installation of plastic blow molding equipment in plants packaging these products.

This slowdown in the growth of beverage markets, coupled with continuing replacement by plastic containers, will result in a growth rate of 1.5 percent per year through 1980, when 43.41 billion glass containers will be used. Beyond 1980, the development of the commercial plastic beverage container will cause demand for glass containers to remain at about the 1980 level. Thus, 1990 use will be 43.31 billion containers.

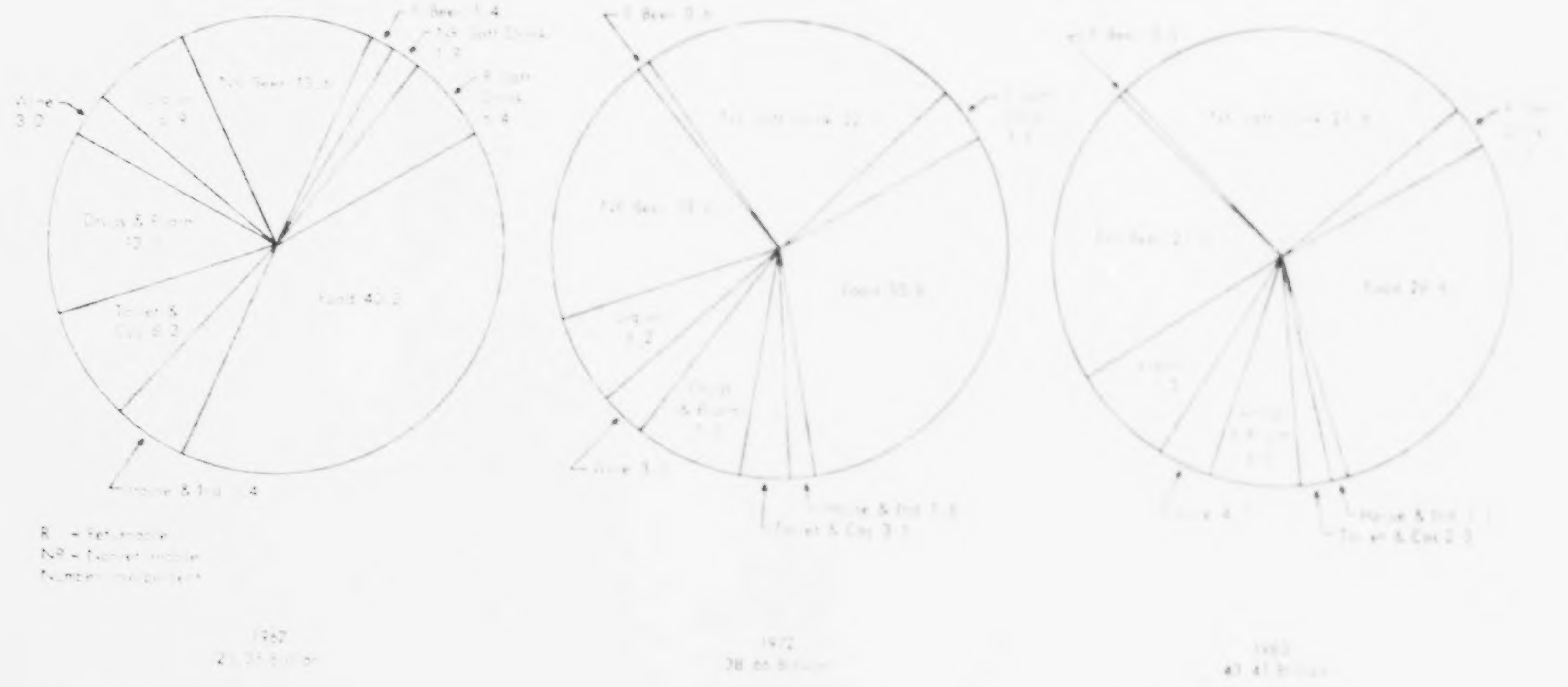
About 250 million containers were exported in 1972. Exports have varied little during the past decade and are projected to remain at this level in the future.

Imports in 1972 were valued at about $9,500,000 and consisted of perfume bottles and other small containers. Quantity estimates are not available, but it is assumed that it is probably about 100-150 million containers. This is a small amount in relation to all containers produced and is not considered a significant factor in solid waste generation. The import of products in glass containers (e.g., whiskey) is an unknown and could not be determined.

Figure 20 shows the market shares by type of containers in 1962-1980. The shares in 1990 will be essentially the same as 1980.

Trends in Container Weight

Although the growth of glass containers has been 4.4 percent per year during the past decade, the average size of the containers has been increasing, resulting in a faster growth for container weight. The average weight of a container in 1962 was 8.6 ounces. This average has steadily increased to 10.1 ounces in 1972. This resulted in the production of 6.75 million tons of glass containers in 1962, which increased at a rate of 6.1 percent per year to 12.22 million tons in 1972.



Sources: U.S. Department of Commerce 1962-1972
NFI Estimates (Wine and Liquor) 1962-1972
NFI Estimates 1980

Figure 20 - Glass Containers Percent by End Uses (Units), 1962-1980

Although nearly all containers have been getting larger, much of the growth in weight has been in the nonreturnable soft drink container which has increased its share of the total container market from 1.9 percent in 1962 to 22.7 percent in 1972. Since the average weight of a nonreturnable soft drink container is greater than the average for all containers, it becomes a major factor in increasing the total weight of all containers. On a weight basis, it represented 27.1 percent of the 1972 tonnage (Table 23).

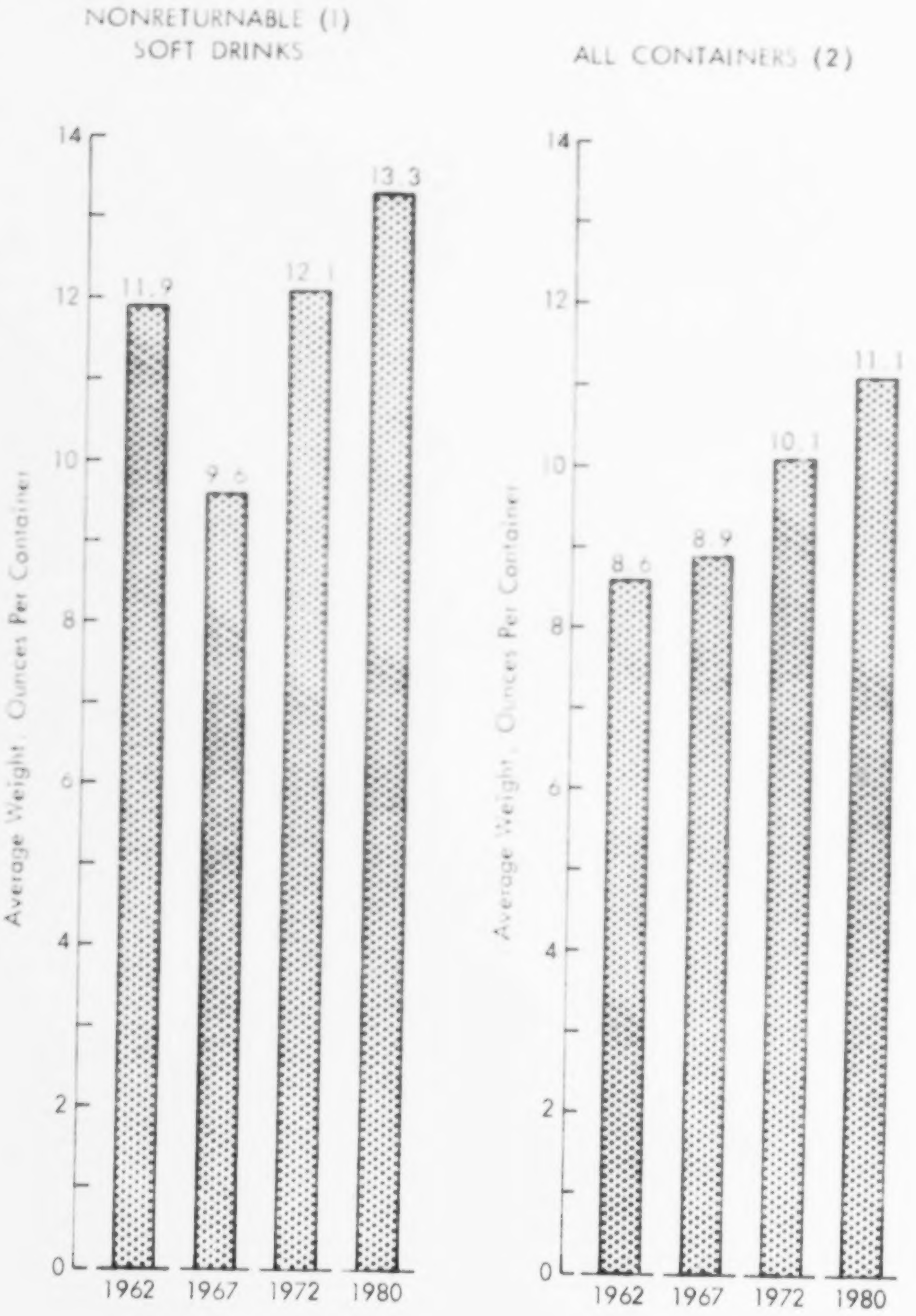
The nonreturnable soft drink container has been increasing in average weight as a result of consumer demand for the 32- and 48-ounce sizes. This has been a recent development which was stimulated by commercialization of the resealable screw top cap. Initially the single-trip container was marketed in larger sizes. As its popularity increased, it was introduced in smaller containers. The average weight steadily decreased to a low of 9.6 ounces per container in 1967. The weight has increased rapidly in the past 3 years, reaching a level of 12.1 ounces in 1972, as more of the large sized containers are purchased by the consumer.

Food containers, which represent 24.7 percent of the weight of all glass containers, have also been increasing in average weight. Much of this increased average weight is a result of a decline in baby food jar production (i.e., a light, small container).

The weight of containers is forecast to increase through 1980, when the average container will weigh 11.1 ounces and then, the average weight will remain at this level from 1980 to 1990. Soft drink containers will continue to cause the average weight to increase as their share of the glass market expands to 25.8 percent by 1980 (Figure 21). Large containers are expected to increase from 14.6 percent of the 1973 soft drink market to 23.6 percent by 1975 at the expense of smaller containers.[91] This would be expected to cause a rapid increase in weight. However, it will be dampened by the acceptance of plastic covered glass containers which weigh less than a comparable glass container. Average weight will increase to 13.3 ounces per container by 1980.

Food containers will also increase in average weight as the recent decline in the birth rate further reduces the demand for the small baby food containers.

The resulting increase in average weight, along with increased demand for containers, will generate a growth rate of 2.6 percent per year from 12.22 million tons in 1972 to 15.11 million tons in 1980, where it will remain essentially constant through 1990 (Figure 22).

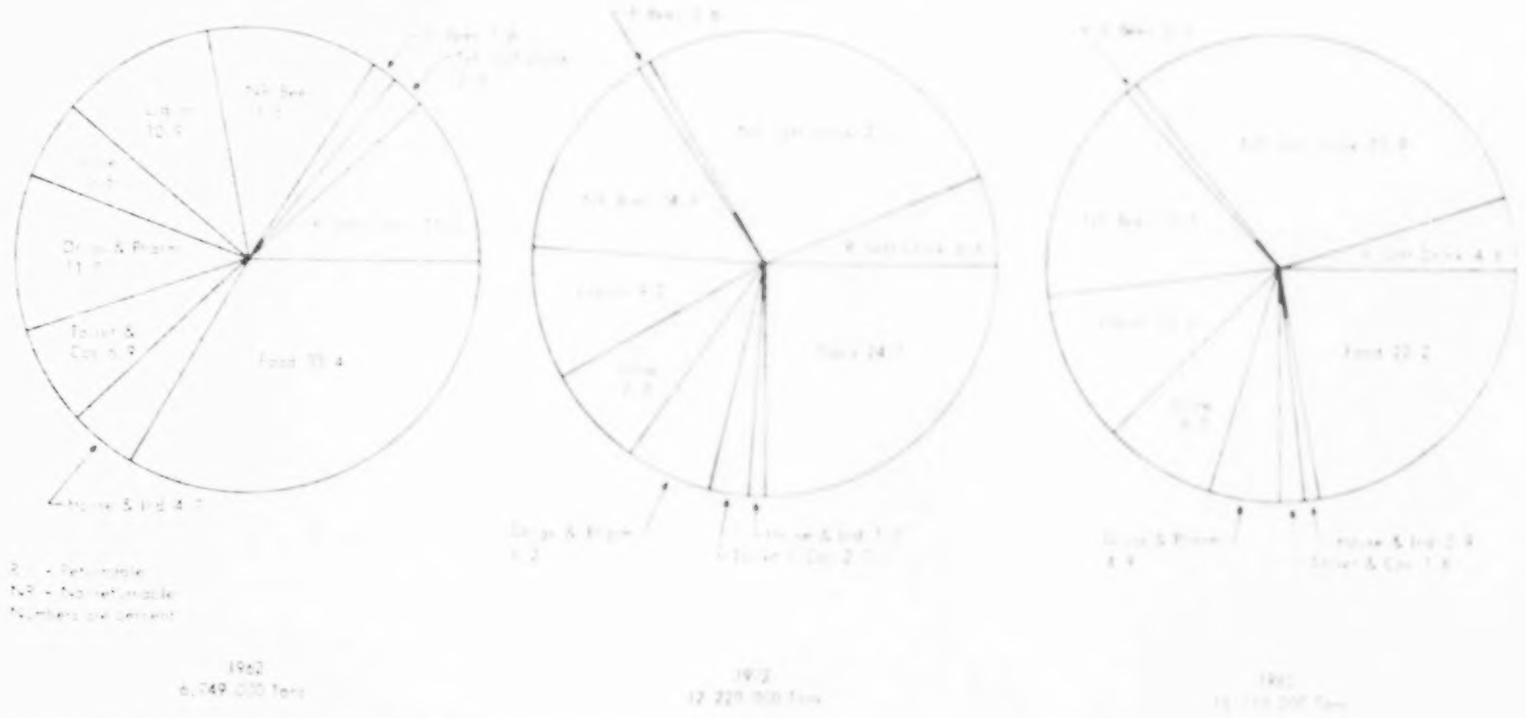


NONRETURNABLE (1)
SOFT DRINKS

ALL CONTAINERS (2)

Source: (1) Glass Container Manufacturers Institute 1962-1972
MRI Estimates 1980
(2) MRI Estimates

Figure 21 - Average Glass Container Weights, 1962 to 1980



Sources: Glass Container Manufacturers Institute Annual Report 1962-1972
MRI Estimate 1980

Figure 22 - Glass Containers Percent of End Uses By Weight, 1962-1980

WASTE GENERATION FROM GLASS CONTAINERS

Glass containers are used primarily to package consumer products. They are manufactured, shipped to a packager, filled and shipped to a retailer. The consumer purchases the container, uses the product, and, with the exception of the returnable container, discards it along with other household waste. This is all assumed to occur within 1 year and in many, if not most cases, is less than 1 month after purchase.

A certain portion of returnable containers are broken, lost or discarded each year. This quantity is approximately equal to the annual production of returnable containers.

It is possible that some products will be in inventory at the producer or consumer level for more than a year and that some containers may be diverted for decorative or other use around the home. The net addition each year is probably very small in relation to the total amount of containers produced so we have not assumed that it is a factor in glass container waste generation.

The above factors are considered to be insignificant in relation to the total glass containers discarded and we have assumed that 100 percent of the containers appear in the solid waste stream essentially as they are manufactured or purchased. This results in a total glass container waste generation of 12.22 million tons in 1972, which will increase to 15.11 million tons by 1980, and remain at that level through 1990.

WASTE GLASS CONTAINER GENERATION BY SOURCE

Glass Containers in Household, Commercial and Industrial Waste

Glass containers will appear as waste from households and apartments as a result of their use by the consumer; from commercial and institutional establishments as a result of over-the-counter sales and direct purchases by institutions; and from industrial establishments primarily from beverage vending machines, containers for research laboratory chemicals and general industrial maintenance chemicals. Table 25 shows the estimated waste generation by each of these categories. The results show that 81.8 percent of the glass containers appear as household wastes; 16.4 percent from commercial and institutional establishments and 1.8 percent from industrial sources. These ratios will vary depending upon the market for the material contained in the glass.

TABLE 25

WASTE GLASS CONTAINER GENERATION, BY SOURCE, 1972
(In thousand tons and percent)

	Household		Commercial and Institutional		Industrial	
	Tons (000)	Percent	Tons (000)	Percent	Tons (000)	Percent
Soft Drinks	3,295	80	618	15	206	5
Beer	1,608	85	283	15	--	--
Liquor	616	55	505	45	--	--
Wine	435	55	373	45	--	--
Food	2,867	95	151	5	--	--
Drug and Pharmaceutical	718	95	37	5	--	--
Toiletry and Cosmetic	301	90	33	10	--	--
Household and Industrial Chemical	138	90	8	5	8	5
Total	9,998	81.9	2,008	16.3	214	1.8

Source: Midwest Research Institute estimates.

Soft drinks: It is estimated that 80 percent of the soft drink glass containers that are disposed each year appear as household waste, 15 percent appear in waste from commercial and institutional establishments, and the balance from industrial facilities. These figures are supported by a recent American Can[96] study shown in Table 26 which shows the amount of soft drinks consumed in the home, through vending machines and in service establishments. Since the homeowner only purchases packaged soft drinks, we have assumed that the 33.7 billion units used in the home in 1970 are packaged drinks and equal to 77 percent of the 43.6 billion total packaged drinks. This share consumed in the home has been getting larger and has increased from 68 percent in 1960. It is likely to have increased further to about 80 percent in 1973.

Another survey of vending products estimates that 5.7 billion bottles were vended in 1972 and that total will rise to 6.8 billion by 1980.[97]

TABLE 26

SELECTED SOFT DRINK MARKET DATA, 1955 TO 1970

	1955		1960		1965		1970	
	Units Billion	Percent	Units Billion	Percent	Units Billion	Percent	Units Billion	Percent
Trend to Packaging								
Packaged	19.7	80.5	23.3	83.0	32.1	86.0	43.6	82.7
Nonpackaged	4.7	19.5	4.8	17.0	5.2	14.0	9.1	17.3
Total	24.4	100.0	28.1	100.0	37.3	100.0	52.7	100.0
End-use Markets								
Home	13.0	53.2	16.1	56.9	24.0	64.3	33.7	64.0
Vending	4.0	16.4	4.9	17.3	6.8	18.2	9.6	18.2
Service	7.4	30.4	7.3	25.8	6.5	17.5	9.4	17.8
Total	24.4	100.0	28.1	100.0	37.3	100.0	52.7	100.0
Low Calorie Trend								
Regular	24.3	99.5	27.8	98.0	32.8	88.0	47.4	90.0
Low Calorie	0.1	0.5	0.5	2.0	4.5	12.0	5.3	10.0
Total	24.4	100.0	28.3	100.0	37.3	100.0	52.7	100.0

Source: American Can Company (Reference 95).

We assumed the use of returnable containers was allocated in the same proportion as the nonreturnable beverage containers in households because no other data were availalbe. Vending accounted for 17.5 percent of all packaged soft drinks in 1972. All of the vended products are used in commercial, institutional or industrial markets. Restaurants and institutional food service organizations also purchased packaged drinks for direct sale or use by occupants. These purchases, plus the vended volume, would increase the use of containers in these markets to 20 percent of the total.

Although data on industrial consumption of bottled soft drinks are not available, it is estimated at 5 percent of the total primarily as vended products. The remaining 15 percent was commercial and institutional use of containers.

Householders use of glass soft drink containers is forecast to stabilize at 80 percent of soft drink containers with the average size in home use increasing. Part of the reason for the percentage decline over time in households is attributed to increasing use of nonreturnable glass in vending machines.

Beer: A study of packaged beer by American Can Company[45] showed an increasing trend toward consumption of beer in the home. Table 27 shows that packaged beer consumed in the home increased from 60 percent of all beer consumed in 1958 to 67 percent in 1967. As a percentage of all packaged beer, it increased from 75 percent to 80 percent during this period. These data restated to reflect consumption on a volume basis are shown in Table 28.

The on-premise markets which include taverns, restaurants, and other commercial establishments that are permitted to sell beer, are largely a market for returnable glass containers. However, about 680 million nonreturnable containers (12 percent of all nonreturnable beer bottles used in 1967) were used on-premise. We estimated that nonreturnables increased to 1.0 billion units in on-premise establishments in 1972, equivalent to 13.2 percent of all beer nonreturnables. If returnables discarded in these establishments are added to the above, the total glass waste generation in on-premise establishments is approximately 15 percent. The balance is generated in households. This basis was used to extend the allocation of beer containers (by household and commercial) to other years.

Liquor: According to the Distilled Spirits Institute, 58 percent of liquor (by volume) is sold for private consumption and the balance is sold through commercial establishments. Commercial establishments use primarily 1/5-gallon containers and the homeowner buys the larger sizes, the ratio on a container weight basis is more likely 55 percent household

TABLE 27

BEER CONSUMPTION BY MARKET, 1949 TO 1967

	1949	1958	1967
On Premise	55%	40%	33%
Draught	30	20	16
Packaged	25	20	17
Off Premise	45%	60%	67%
Canned	9	28	35
Nonreturnable Bottled	2	5	14
Returnable Bottled	34	27	18
Total Sales	100%	100%	100%

Source: American Can Company.93/

TABLE 28

BEER CONSUMPTION BY MARKET AND CONTAINER TYPE, 1967

	Million Barrels			Billion Containers (On Premise)
	Total	Off Premise	On Premise	
Metal Cans	41.2	37.5	3.7	1.24
Bottled (Nonreturnable)	17.0	15.0	2.0	0.68
Bottled (Returnable)	31.4	19.3	12.1	4.00
Draught	17.4	--	17.4	--
Total	107.0	71.8	35.2	5.92

Source: Midwest Research Institute based on Table 27.

and 45 percent commercial and institutional. No significant ratio changes were forecast for the future.

Wine: Wine usage was assumed to be consumed similar to liquor with 45 percent being sold in restaurants and other eating establishments and the balance being consumed in the home. This ratio should change in the future to a greater share used in the home because of the rapid growth of the lightly carbonated "pop wines." By 1980, the ratio will be 60 percent in the home and 40 percent in commercial establishments.

Food: It is estimated that 95 percent of the food containers are used in households with the balance in commercial and institutional establishments. Commercial establishments purchase food in larger sizes that are usually packaged in metal cans or drums, thus a high percentage of glass food containers are sold to householders. Condiments such as catsup and sauces used directly in restaurants are packed in glass. No change is anticipated in this ratio in the future.

Toiletries and cosmetics, medicinal and health, household and industrial chemicals: These items are predominantly consumer products that are used in the home. Medicinal and health products are also used in hospitals and medical dispensaries, while cosmetics and toiletries are used in beauty parlors and other commercial establishments, or are used and disposed of by people living and working in institutions or commercial facilities. Household and industrial chemical products are used for cleaning buildings and offices, and to contain chemicals used in industrial facilities. No change is anticipated in these markets that would alter the ratios given in Table 25.

Glass Containers in Litter

Some glass containers are discarded to become litter along roadsides, in parks and on beaches. Numerous litter surveys have been conducted by groups throughout the country and most of these have identified the beverage container as the glass component of the litter. One comprehensive study of litter was published by Research Triangle Institute.81/ This study estimated that 596 million glass beverage containers were littered in 1969. This is equivalent to 3.9 percent of all glass beverage containers produced that year and 1.6 percent of all glass containers produced. The writers admit the study has limitations since there are no comparable historical data to identify trends. It also covered only interstate and primary highways, and excluded parks, beaches and recreational areas.

Assuming the findings are reasonable and that about half of the litter is collected by maintenance crews, then approximately 2 percent of all glass beverage containers are unrecovered each year. This would result in a net litter component of 120,000 tons of glass in 1972.

With increased public awareness of litter and laws being enacted in states that tax beverage containers, it is likely that the litter component will decline over the next 2 decades or at least remain at the current level. Thus, we assumed that 2 percent of all beverage containers produced each year will remain on the ground as uncollected litter. This will result in 156,000 tons per year of litter in the waste stream by 1980. All of this glass container litter will be diverted from household waste since it is the result of consumer purchases and the net waste discards from households will be reduced as shown in Table 29.

TABLE 29

HOUSEHOLD WASTE GENERATION OF GLASS CONTAINERS
(In Thousand Tons)

Category	1972	1975	1980	1985	1990
Total Household	9,998	10,956	12,223	12,223	12,223
Litter	120	136	156	156	156
Net Discarded From Homes	9,878	10,820	12,069	12,069	12,069

Source: Midwest Research Institute.

Future glass container waste generation will continue to be mostly from households. Household waste generation will decrease slightly from 81.6 percent in 1972 to 80.7 percent in 1980, as nonreturnable containers come into more widespread use in commercial establishments (as a percent of total containers). Total waste generated from households will increase from 9.88 million tons in 1972 to 12.07 million tons in 1980 and 1990 as shown in Table 30.

TABLE 10

GLASS CONTAINER WASTE GENERATION BY SOURCE, 1972-1990[1]

	1972		1975		1980		1985		1990	
	Tons (000)	Percent	Tons (000)	Percent	Tons (000)	Percent	Tons (000)	Percent	Tons (000)	Percent
Households	9,878	81.6	10,822	81.3	12,069	80.7	12,069	80.7	12,069	80.7
Commercial and Institutional	2,008	16.6	2,243	16.9	2,611	17.5	2,611	17.5	2,611	17.5
Industrial	214	1.8	242	1.8	276	1.8	276	1.8	276	1.8
Total	12,100	100.0	13,307	100.0	14,956	100.0	14,956	100.0	14,956	100.0

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[1] With Litter deducted from the totals.
Source: Midwest Research Institute.

GLASS CONTAINERS RECOVERABLE FROM WASTE

The quantity of glass containers recoverable from waste was determined by assuming that only the population within Standard Metropolitan Statistical Areas (SMSA's) as defined by the Bureau of Census would be large enough to sustain glass recovery from waste. In 1972, 68.6 percent of the total population of the United States resided in SMSA's.[98] This percent has been increasing as more areas are added to the SMSA and the population continues to locate in urban areas. The National Planning Association projects SMSA population to increase to 70.5 percent by 1980, and assuming that trend continues, it should be 71.7 percent by 1990.*

We have assumed that 68.6 percent of the household waste is potentially available for collection and resource recovery, i.e., that amount that occurs within SMSA's. Commercial, institutional and industrial waste is estimated using employment in metropolitan areas. The percentage of commercial and institutional employees in SMSA's was 73.6 percent in 1970, and the percentage of agriculture, mining and manufacturing employment in SMSA's was 64.3 percent. Assuming that waste generation is proportional to employment, these ratios were used to develop the potential waste recovery in these areas. We also assumed that these percentages will increase in proportion to the total population in the SMSA. A summary of these percentages are shown below in Table 31. Using the Table 31 ratios, the projected waste generation within the SMSA from 1972-1990 was calculated (Table 32).

TABLE 31

WASTE GENERATION IN SMSA'S AS A PERCENT OF ALL WASTE

Source	1970	1972	1975	1980	1990
Household	66.2	68.6	69.3	70.5	72.7
Commercial and Institutional	73.6	74.0	74.8	76.1	78.4
Industrial	64.3	64.7	65.4	66.5	68.5

Source: Midwest Research Institute based on National Planning Association; U.S. Bureau of Census - Industry of Employed Persons by Metropolitan and Nonmetropolitan Residence, 1970.

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* Note however, that while urbanization is continuing, the growth of suburbs has been rapid while central cities have declined. Whether the trend will continue is not known. However, the population concentration in urban areas will likely continue in the future.

TABLE 32

GLASS CONTAINER WASTE GENERATION IN SMSA'S, 1972 TO 1990
(In Thousand Tons)

Source	1972	1975	1980	1985	1990
Household	6,775	7,498	8,509	8,645	8,770
Commercial and Institutional	1,480	1,679	1,987	2,020	2,045
Industrial	135	158	184	185	185
Total	8,390	9,335	10,680	10,850	11,000

Source: Midwest Research Institute

GLASS CONTAINER RECYCLING FORECASTS, 1972 TO 1990

Current Recycling Practices and Separate Collection

Glass recycling has always been practiced by the glass industry since a certain percentage of waste glass added to the glass furnace improves the operating efficiency through reduced fuel consumption and improved melting time. Normally, cullet (waste glass) use is 10-20 percent of the glass batch. Cullet is usually available from off-specification bottles rejected from the bottle forming machines and from other scrap within the glass plant. Multiplant companies will often ship from a plant that produces excess cullet to one that is dificient. Some purchases may be from external sources. These may be from bottling plants or from cullet dealers. It is estimated that about 100,000 tons of cullet were purchased from sources outside of glass plants in 1972.

The ideal material is the in-plant scrap, since it is of known quality, is color sorted, and is free of dirt, organics and metal contaminants. The best source of purchased cullet is beverage bottling plants since the cullet is color sorted and of generally good quality. Most of the purchased cullet is broken containers from bottling operations or rejects from returnable bottle washing operations. Glass container manufacturers may purchase the cullet directly from the bottler and return it to the glass plant in drums or other containers on the same truck that delivered the glass bottles; or they will purchase from cullet dealers that buy from the bottlers.

This latter source of cullet is declining as bottling operations increase their efficiency and process fewer returnable containers. Cullet dealers are a declining source of glass because of the high cost of labor and the rarity of good quality cullet. Many resort to hand sorting the colors which is extremely expensive. There were less than 20 dealers in 1971, and they have declined in number further since then.[84]

A second source of purchased cullet is public volunteer collection. This source resulted in the collection of close to 700 million containers in 1972, equivalent to 175,000 tons of glass.[92] This program was begun in recent years and has been a cooperative effort of the members of the Glass Containers Manufacturers Institute who have agreed to accept this glass at 90 plants.

Because cullet quality is the lowest of all sources of purchased glass, volunteer collection programs are viewed as an interim step to the recycling of glass from municipal waste. The glass manufacturer needs the material color sorted, reasonably clean and free of caps and neck rings. The housewife, Boy Scout and any other concerned citizen who collects the containers for recycling in the home or from roadside cleanup projects may allow occasional metal cans, cups, paper, plastics, rags or wood to be included with the glass. When collection from voluntary collection programs was small, the glass plants could cope with these tramp materials. When volunteer collection is substantial, mechanical clearing systems should be used at glass plants to upgrade the quality of the incoming cullet.

Owens Illinois, whose Charlotte, Michigan, plant purchased over 42 million pounds of glass in 1972, found it necessary to develop a cullet processing system in their facility. The system is designed to handle 22 tons of cullet per hour. The cullet flows to a bottle crusher before being conveyed to three vibrating screens which segregate the materials by size. The facility also includes a vacuum system to remove aluminum, wood, paper, plastics and rags and a magnet to remove iron. If this system is successful, the company may install it in other plants.[99]

The future of recycled glass from source separation systems is limited. Sources of cullet from dealers and bottling plants are reduced by the decline in returnable beverage and milk containers. Consumer collection systems are limited by the degree of interest of consumer groups to collect and return the containers to a collection center. There is some evidence that this source is leveling off now. Collections in 1971 were nearly the same as 1972 at 691 and 692 million units respectively. Some moderate growth is anticipated to 1980, but it will remain level beyond this time as municipal resource recovery systems are developed and implemented. By 1975, 180,000 tons per year will be recovered from volunteer collections. This will increase to 230,000 by 1980. Purchased cullet is expected to decline to 80,000 tons by 1975 and 50,000 by 1980 (Table 33).

TABLE 33

GLASS CONTAINER WASTE AVAILABLE IN SMSA'S, 1972 TO 1990

(In Thousand Tons)

	1972	1975	1980	1985	1990
Waste Generated in SMSA's	8,390	9,335	10,680	10,850	11,000
Less volunteer collection	175	180	230	250	250
Less cullet dealers	100	80	50		
Net waste	8,115	9,075	10,400	10,600	10,750

Source: Midwest Research Institute.

Recovery of Glass Containers from Mixed Municipal Waste

It is apparent that if any significant recycling of glass is to be achieved, it must come from resource recovery systems in major metropolitan areas. A total of 8.1 million tons of glass containers in 1972 are available within the SMSA's and this will increase to 10.4 million tons in 1980.

Glass from a resource system may be recycled by selling it as cullet for use by glass container manufacturers as a substitute for raw materials (soda ash and sand). Recovered glass may also be used as a raw material in other products such as glass wool, terrazzo, bricks, or road paving mixtures.[*] These latter uses do not require a stringent specification glass except for terrazzo.

The recovery of glass in any form is highly dependent upon the method used to dispose of the solid waste, since the glass fraction must be separated from the organic and other inorganic materials. If mixed solid waste is to be processed, it requires a system to first reduce the size of the waste followed by separation to remove the organic materials and magnetic separation to remove the ferrous metals. Additional separation techniques will be necessary to remove aluminum, other metals, stones and pottery, before a good quality glass container cullet fraction can be produced.

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[*] Certain marketing difficulties exist here too. On the one hand, the amount of cullet generated is too low to make much of a contribution to road paving material requirements; on the other hand, the other uses are very low volume and specialized in comparison to the tonnage of container cullet generation.

Thus, recovery of glass from mixed municipal waste will be part of a total recovery system which will use the organic fraction as fuel or will separate inorganics for recovery and recycling. Recovery of glass will be an "add-on" feature, since the waste material could be disposed o in a landfill rather than separated to remove the glass.

At the present time, there are no commercial systems in operation to recover glass from mixed municipal wastes. Perhaps the closest system is the Franklin, Ohio, Environmental Control Complex. This system includes separation of the organic fraction, consisting primarily of paper and plastics which is used in the manufacture of roofing felt and separation of magnetic iron for sale to steel companies. An experimental glass and aluminum classification system is now being operated at Franklin.

The Franklin, Ohio, plant consists of a hydropulper which reduces the waste in particle size to less than 3/4 inch in a liquid medium. The oversized material is withdrawn from the hydropulper and the iron removed by magnetic separation. The remaining oversized material which consists of about 80 percent glass, along with aluminum, iron, rock, porcelain and organics, is processed through an experimental glass recovery system. The glass recovery system consists of a furnace to burn off the remaining organics, an air classification system to remove the aluminum, and an optical system to separate the glass into amber, green, and flint fractions. It is anticipated that this system will produce a product good enough to use as cullet in glass container furnaces. The glass is being shipped to Owens Illinois in Toledo, Ohio, where it will be evaluated.

The glass recovery of this system is estimated at about 55 percent of the glass fraction in the waste. Since it is still experimental, it is expected that the rate of recovery will increase as improvements are made in the system. An additional 25 percent of the glass is lost as fines in the fiber recovery system. An air classification system could increase the recovery by removing the glass from this fraction, but at the present time, this is not planned.

There are other systems which could possibly recover glass. These are: the Garrett Research process, the CPU 400 energy recovery process, and the U.S. Bureau of Mines Incinerated Wastes recovery process.83/ The Garrett process is designed to recover salable heating fuels, glass, and magnetic metals. The waste is shredded and air classified to remove the inorganic glass and metal fractions. The glass can be recovered via a froth flotation process as a very fine, highly pure noncolor sorted glass. A Garrett pyrolysis plant is under construction, in Southern California that will have a glass recovery unit.

The U.S. Bureau of Mines Incinerator Residue Recovery Process is designed to recover iron, nonferrous metals and glass from incinerator residues. The system consists of a series of screening and shredding operations designed to reduce the material by size and separate. The ferrous metals are removed by magnetic separation and the glass is removed by a high density magnetic separator which separates the colored from the colorless glass.

Dry recovery systems have not been tested in commercial operation. One difficulty of recovery of glass from dry recovery processes is that in shredding dry refuse the glass shatters and produces nonuniform particles and "fines." Recovery must then rely on a media separation process and recovery of glass in noncolor sorted form. Until this technology advances, the recovery of color sorted glass from dry shredding will be limited and relatively inefficient.

We conclude that recovery of glass from municipal refuse is not commercial at the present time. Although there are experimental systems, the quality of the glass which will come from these units can only be estimated. However, the technology for producing a recyclable glass fraction is developing. Glass recovery technology will be tested in the next few years and commercial glass recovery systems should be available for resource recovery installations by the early 1980's.

Recovery Forecasts for Glass Containers

The future of the recovery of glass will depend upon the quality of the glass available from resource recovery systems and the economics of recovery of various grades of glass. The economics of recovery will include not only the process, but also the transportation to the user (which could be significant) and the price which the user is willing to pay.

The largest market for glass recovered from mixed municipal waste would be as cullet for glass container manufacturing plants. However, high quality material will be required since present standards require color sorting into flint, amber, and green glass that is free from organics, magnetic metals, refractory inorganics, and nonmagnetic metals. A limited amount of material which is being used in test batches has been available from resource recovery systems.

Because of the current lack of waste glass from resource recovery systems, the glass companies have not been able to evaluate the quality of cullet to see if it could be accepted in glass furnaces. If a good quality cullet is available, they estimate they can use at least 30 percent cullet in their furnace operation. There is also the possibility that the glass plants may add facilities to upgrade cullet at the manufacturing plant such as the experimental unit at Owens Illinois' Charlotte, Michigan, plant.

Markets may be developed for lower quality glass, but most of these have included experiments with higher quality cullet, available from manufacturing plants or from volunteer collection groups. Development of secondary glass product markets does not appear to be something that will take place rapidly because of the specialized nature of the end uses to which glass is adaptable.

The economics of any glass recovery system will be important. Presently and for the forseeable future, cullet must compete with the raw materials of glass manufacture which are primarily soda ash and sand. These are readily available raw materials with known deposits in the United States of more than 100 years' supply (although there have been reported shortages of soda ash recently because of a shortage of industrial capacity to produce and ship this material). The cost of these materials should not increase any faster than the wholesale price index for all commodity materials. Current estimates are that the glass container manufacturers could pay about $20 per ton for a "specification" cullet. The transportation costs which could be significant, must be subtracted from this figure. The cost of shipping the glass from Franklin, Ohio, to Toledo, Ohio, a distance of about 200 miles, is estimated at $10 per ton. It is possible that with larger volume shipments, the rate would be reduced to about $7 per ton. Thus, if a glass plant is too far from the resource recovery center, the transportation costs could be a real economic barrier to using the glass as cullet. Glass plants are not uniformly located in the USA; thus in some regions, shipping costs would preclude recycling.

Considering all these factors, forecasting the amount of glass that will be recycled in the future becomes largely a matter of judgment. Although we have predicted the installation of 12 centralized resource recovery systems by 1980, and 60 systems by 1990, it is doubtful that all of these will be recovering glass without some form of external economic incentives.

We have made our glass recovery forecasts based upon the following judgments:

1. That technology now in the experimental and demonstration stage will be commercialized to make waste glass available in a quality that can be used as cullet by glass manufacturing plants. It will be color sorted into flint, amber, and green fractions. It will also be a lower quality than cullet from internal operations.

2. Economic incentives will be provided to stimulate the use of cullet by glass manufacturers or recovery systems will be subsidized directly or indirectly by the recovery of other components of solid waste in centralized waste recovery operations. This is under the assumption that soda ash will not be in short supply in the future.

3. Glass recovery from mixed waste is dependent upon processing of other components of the waste stream for recovery in central facilities. In addition, only 30 percent of these facilities will be located within economic shipping distance of glass container plants. Thus, glass recovery systems will be installed for about 30 percent of the total mixed waste tonnage processed for recovery of all kinds (as summarized in Chapter II). The mechanical efficiency of recovery systems will be: 0.55 in 1975; 0.60 in 1980; 0.65 in 1985; 0.70 in 1990.

4. Other uses for waste glass of a lower quality in secondary products will be developed on a very limited basis in locations where glass plants are remote and transportation would be prohibitive.

The recovery of glass for recycling from mixed waste is summarized in Table 34. We estimate that four plants will have glass recovery systems on-stream in 1980; 11 plants in 1985; 18 plants in 1990. (Glass recovery from mixed waste will pass from experimental and demonstration status after 1975, so we have estimated no commercial glass recovery system installed by 1975.) The total mixed waste processed for glass recovery will rise from 1.6 million tons in 1980 to 10.2 million tons in 1990. Based on the glass content of mixed municipal waste and the mechanical efficiency of glass recovery systems, we calculated that glass recovery will be 100,000 tons in 1980; 350,000 tons in 1985 and 600,000 tons in 1990.

A summary of all glass waste recovery (overwhelmingly glass containers) is shown in Table 35. Only 1.8 percent of the total available glass waste will be recovered in 1975; 2.3 percent in 1980 and 5.0 percent in 1990. On the basis of glass container waste generated in SMSA's only, the recovery percentage will be: 1975, 2.9 percent; 1980, 3.5 percent and 1990, 7.7 percent. Our estimate of actual glass recovery is relatively low, especially in comparison with some of the other materials evaluated in this study. However, on the basis of the above assumptions, the reocvery forecasts appear to be realistic.

TABLE 34

GLASS RECOVERY FROM MIXED MUNICIPAL WASTE, 1972 TO 1990
(In Thousand Tons)

Year	Total Mixed Waste Generated	Total Glass Waste Generated	Total Glass Container Waste Generated	Percent Of Glass In Waste	Number of Resource Recovery Plants Recovering Glass	Total Mixed Waste Processed For Glass Recovery	Total Glass Available In Processed Waste	Recovery Efficiency	Glass Recovery
1972	130,000	13,200	12,220	10.1	none	none	none	--	--
1975	140,000	14,500	13,440	10.5	none[1]	neg.	neg.	0.55	10[1]
1980	160,000	16,400	15,110	10.3	4	1,650	170	0.60	100
1985	180,000	16,600	15,110	9.3	11	5,800	540	0.65	350
1990	200,000	16,900	15,200	8.4	18	10,200	860	0.70	600

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[1] Except three demonstration units under EPA demonstration grants

Source: Midwest Research Institute.

TABLE 35

SUMMARY OF GLASS CONTAINER RECYCLING, 1972 TO 1990

(In Thousand Tons)

Category	1972	1975	1980	1985	1990
Total Waste Glass generated[1/]	13,220	14,500	16,400	16,600	16,900
Glass Recovery:					
Volunteer collection	175	180	225	250	250
Cullet dealers	100	85	50		
Waste recovery plants	--	10	100	350	600
Total	275	275	375	600	850
Net Waste Glass Disposal	12,925	14,225	16,025	16,000	16,050
Percent Recovery for Recycle:					
Of total	2.8	1.8	2.3	3.6	5.0
Of container glass generated in SMSA's	3.3	2.9	3.5	5.5	7.7

Source: Midwest Research Institute.

1/ Includes noncontainer glass.

CHAPTER VI

RECOVERY FORECASTS FOR FERROUS METALS TO 1990

SUMMARY

Total ferrous metals in mixed municipal waste will increase from 11.1 million tons in 1972 to 16.4 million tons in 1990. Excluding bulky wastes, 6.4 million tons were generated in SMSA's in 1972 and 11.7 million tons will be generated in SMSA's in 1990.

The demand for steel cans will increase from 5.6 million tons in 1972 to 6.1 million tons in 1990, indicating mature markets for most uses. On a unit basis, this is 65.7 billion units in 1972 to 84.3 billion units in 1990. Beverage can growth will be high, but will be predominantly in aluminum and plastic, rather than steel.

In addition, major household appliances and other bulky items accounted for another 1.8 million tons of ferrous metal waste in 1972 and will rise to 2.9 million tons in 1990. Of this, 1.2 million tons were in SMSA's in 1972 and 1.9 million tons will occur in SMSA's in 1990. On a source basis, about one-third of all appliances are discarded directly from households, and the remainder are discarded from commercial establishments.

The recovery of ferrous metals in waste will be closely tied to the installation of centralized waste processing facilities. Ferrous metals can be readily removed and upgrading carried out to meet steel scrap specifications. In general, the recoverable steel scrap in mixed municipal waste can be recycled in steelmaking furnaces, scrap exports, or in copper precipitation, and iron foundries. The "contamination" levels from tin, lead and copper (in cans) would be too low to inhibit recovery and recycling per se since the absolute amounts are relatively small. Technical limitations do not appear to be a significant factor in recovery and recycling of ferrous metals.

In addition to recovery of ferrous metals from large centralized resource recovery systems, there will be some recovery from separate "front end" magnetic separation systems at landfills, transfer stations and the like. Almost all steel scrap recovery will take place in SMSA's because of the population density required to justify recovery systems.

MRI's forecasts of recovery of ferrous metals to 1990 are summarized in Table 36.

TABLE 36

SUMMARY OF FERROUS METAL RECOVERED FROM MUNICIPAL WASTE
1972 TO 1990
(In thousand tons)

Recovery From	1972	1975	1980	1985	1990
Volunteer collection, incinerator residue, magnetic separation	68	153	180	205	220
Centralized recovery system	0	127	395	1,450	2,815
Appliance processing	2	5	15	60	100
Total	70	285	590	1,715	3,135
Ferrous waste generated					
Total U.S.A.	11,100	11,700	13,100	15,200	16,400
SMSA's (nonbulky only)	7,585	8,110	9,220	11,495	13,600
Recovery as a percent of					
Total ferrous waste	0.6	2.4	4.5	11.3	19.1
Ferrous waste in SMSA's	0.9	3.4	6.2	14.4	22.5

Source: Midwest Research Institute forecasts.

The recovery of ferrous metals from mixed municipal waste and appliances for recycling of all types will rise from 70,000 tons in 1972 to 3.2 million tons in 1990. This will be a rise from 0.6 percent of available waste ferrous metal in 1972 to 19.1 percent in 1990. After 1980, recovery at centralized waste processing plants will dominate and will account for 87 percent of total recovery by 1990. Most of the recovered metal will go to steel furnaces and blast furnaces.

RECOVERY OF FERROUS METAL CANS AND MISCELLANEOUS METAL WASTE

Introduction

In 1972, 76 billion metal (steel plus aluminum) cans were used. The metal can was developed over 160 years ago and now finds its widest use in packaging food and beverages. Most perishable foodstuffs can be stored in cans for long periods of time and still retain the basic color, flavor and nutritional value of the fresh product. These factors, along with its low cost and resistance to damage, have been the reasons for its success. The "convenience" of the can, combined with unbreakability, lightweight and easy-open tops, has also made it a popular container for soft drinks and beer which have been the fastest growing end uses for cans. In one decade, beverage cans increased from 22.3 percent of the total can output to 49 percent (on a unit basis).

Metal Can Demand by Market, 1962 to 1990

The demand for metal cans (steel plus aluminum) has been increasing at a rate of 4.7 percent per year since 1962 and reached a level of 76 billion units in 1972. Demand for cans will increase at 3.3 percent per year through 1980, to a level of 98.8 billion units. Beyond 1980, growth will be at a relatively modest 1.7 percent per year and demand for 117.1 billion metal cans will be achieved in 1990 (Table 37).

TABLE 37

METAL CAN DEMAND, 1962-1990
(In millions of cans and thousand tons)

End Use	1962[a]	1972[b]	1975[b]	1980[b]	1990[b]
Soft drinks	1,651	15,600	19,200	24,600	30,000
Beer	9,075	21,600	26,500	33,500	44,500
Food	31,412	31,300	31,500	32,000	33,000
Aerosols	1,042	2,800	3,200	4,000	4,900
General packaging	4,980	4,700	4,700	4,700	4,700
Total	48,160	76,000	85,100	98,800	117,100
Metal (tons)					
Steel	5,590	5,659	5,805	6,112	6,415
Aluminum[*]	403	587	813	1,137	1,600
Total	5,993	6,246	6,618	7,249	8,015

Sources: [a] Can Manufacturers Institute
[b] MRI estimates.
[*] Includes aluminum ends for cans.

Nearly all of the growth in recent years has been in soft drink and beer containers where metal cans are increasing their share of these markets at the expense of returnable glass containers. This growth rate will slow during the rest of this decade as the decline in returnable glass containers stabilizes, as plastic containers come onto the scene, and as soft drink demand increases at a slower rate. By 1980, beer and soft drink cans will amount to 58.8 percent of all metal cans (Figure 23).

Soft drinks: Demand for metal soft drink cans expanded rapidly from 1.65 billion units in 1962 to 15.6 billion units in 1972. The pull-tab can has been credited with the success and widespread consumer acceptance. During this period, metal cans increased their share of the packaged soft drink market from 6 percent to 34 percent.

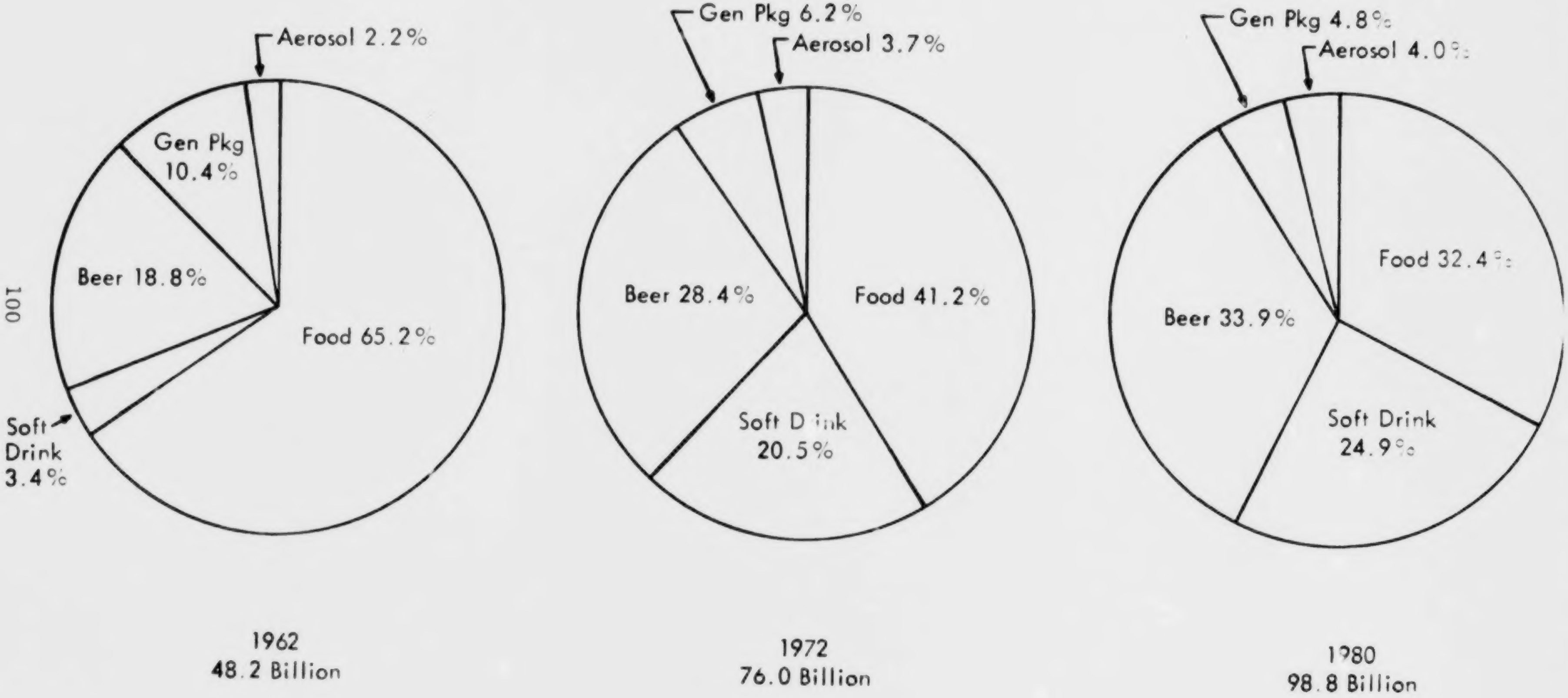
Metal cans will continue to increase their share of the packaged soft drink market, reaching 42 percent by 1980 before declining slightly to 41 percent by 1990 as the all-plastic beverage containers capture much of the growth in the packaged soft drink market. Demand for metal soft drink cans will increase at 5.9 percent per year to a level of 24.6 billion cans by 1980. Beyond 1980 as the growth in soft drinks matures, cans will increase at 2.3 percent per year to 30.0 billion in 1990 (Table 37).

Beer: Metal cans have been the preferred container for the beer consumer. Cans have increased from 37.1 percent of the packaged beer market in 1962 to 58 percent in 1972. Demand for metal cans increased at 9.0 percent per year during this period from 9.1 billion units in 1962 to 21.6 billion units in 1972.

The consumer's preference for the lightweight "easy open" can will continue as it increases its share of the beer market to 63.5 percent in 1980 and 65.5 percent in 1990. The growth rate will begin to slow as the decline in the returnable glass container levels out. Growth will be at a rate of 5.6 percent per year to a level of 33.5 billion cans in 1980 and then at 3.1 percent per year to 44.5 billion in 1990 (Table 37).

Food: Food containers have been the largest single outlet for metal cans. There has been no growth in this market with 1962 demand of 31.2 billion containers almost the same as the 1972 demand of 31.4 billion units. Declining demand for canned fruits and juices, evaporated and condensed milk, lard, shortening and coffee have been offset by increased demand for baby foods and formula, vegetables, juices and pet foods. These patterns should continue in this stable market and demand will increase slightly to 32.0 billion cans in 1980 and 33.0 billion in 1990 (Table 37).

Aerosols: Aerosols have been a small but rapidly growing market for metal cans. They are widely used to package household cleaning and polishing chemicals and personal care products such as hair sprays.



Source: Can Manufacturers Institute 1962
MRI Estimates 1972-1980

Figure 23 - Metal (Steel plus Aluminum) Cans Market Share (Percent), 1962-1980

Demand has grown at 10.5 percent per year from 1.04 billion containers in 1962 to 2.82 billion in 1972.

A lack of new product innovations, coupled with increasing market saturation, will reduce the growth to 4.4 percent per year to 1980 when demand will be 4.0 billion containers. Growth to 1990 will be 2 percent per year reaching a level of 4.9 billion units (Table 37).

General packaging: General packaging includes paint, oil, antifreeze and a host of miscellaneous can markets. Demand in 1972 at 4.7 billion containers is slightly less than the 1962 demand of 5.0 billion units. Although miscellaneous uses have grown during this period, they have been offset by a decline in oil and antifreeze cans and relatively little growth in paint cans. Oil cans were replaced by fiber-foil cans in 1963 and 1964 and have remained at that level. Metal antifreeze cans are being replaced by plastic containers.

Demand is projected to remain at the present level of 4.7 billion units through 1990 as plastic containers begin to replace paint cans and continue to replace antifreeze containers (Table 37).

Metal Can Demand by Type of Metal

Technology: Metal cans have been in use in the United States for over 160 years, but until recent years they were nearly all manufactured from tin-coated, cold-rolled steel called black plate. This can is a three-piece system consisting of two ends and a body which are formed and soldered with a lead-tin solder. Many of the cans are enamel coated to increase their resistance to corrosion.

Until 1960, the tin plated steel can ruled supreme in the can industry. There were some products, e.g., oil, which were packaged in a coated black plate can. These cans were developed during World War II when a shortage of tin developed. These cans, which are caulked, are limited to use in markets where pressure or vacuum are absent and corrosion is not a problem.

The development of the aluminum can and the installation of can manufacturing equipment by beer companies spurred the can manufacturers and steel companies into research for new and lower cost methods of producing cans from steel. Working with the steel industry, American Can and Continental Can, the two largest can manufacturers, developed their own processes using a new tin-free steel that was 15 to 20 percent lower in cost than tin plate. This product was essentially black plate steel with a chromium metal-chromium oxide treatment to render the surface chemically inactive long enough for an enamel coating to be applied. American Can chose to commercialize a three-piece cemented side seam (Miraseam^R) and Continental Can commercialized the three-piece can with the welded side seam (Conoweld^R). Tin-free steel gained rapid acceptance in the beverage industry and now accounts for 42 percent of steel beverage cans. Ends for food cans and other canned products are also produced from tin-free steel which can be used in any market where an enameled coating will be an adequate protective coating.

The future of tin-free steel is highly dependent upon American Can Company and Continental Can Company since they are the only firms to have commercialized the technology for using tin-free steel in three-piece can bodies. Continental Can has publicly stated that all of their soldered beverage can lines will be phased out within 5 years and American could well do the same.[100/] None of the other can manufacturers have chosen to license the technology of Continental or American.

There are two recent developments which will bear upon the future choice of can stock. These are the development of the two-piece drawn and ironed steel can and QAR Steel.

In their pursuit of lower costs, the can manufacturers are evaluating QAR (Quality as Rolled) steel. This material is black plate that has been double-reduced, and annealed but not cleaned, lubricated, or chrome-coated. This material is lower in cost than tin-free steel because fewer processing steps are needed. It must be enamel-coated soon after manufacture since it does not have the corrosion protection of tin-free steel.

Another recent technological development is the two-piece drawn and ironed steel can which, if successful, could compete with the aluminum can. This can will weigh approximately 25 percent less than a comparable three-piece can and have the same features as the aluminum can.

At the present time, it must be manufactured from electrolytic tin plate. The tin is claimed to provide lubricity during the ironing step and this increases the speed at which the cans are manufactured. Tin-free steel can only be drawn to a length equal to its diameter or the ironing step will break the chromium coating and allow metal corrosion to take place. Current research efforts are directed at using black plate or QAR steel and indications are that this technology could be commercial by 1977.

The two-piece drawn and ironed steel can are now commercial, but the volume is small. National Can and American Can have installed lines to manufacture these cans and one of their initial customers was Schmidt's brewery in Philadelphia.[101/]

It is likely that the drawn and ironed steel can will be pushed by the smaller can manufacturers since they have not chosen to license or commercialize the cemented or welded three-piece can. Although American Can and Continental Can have constructed can lines to manufacture their three-piece proprietary systems, they are also building plants to produce two-piece cans.101/

Markets: The new developments in can manufacturing technology in the past 5 years gives several options when additional canning capacity is needed. Essentially, fabrication choices will be between a two-piece can and a three-piece can. Several types of metals and methods of manufacture will also be available. These choices are:

* Three-piece can -
    - soldered electrolytic tin plate
    - welded tin-free, QAR or black plate steel
    - soldered tin-free, QAR or black plate steel
    - caulked black plate
* Two-piece drawn and ironed can -
    - aluminum
    - electrolytic tin plate
    - black plate

The ultimate choice made by canners will depend upon the competitive economics in the particular markets for which the cans are being manufactured.

MRI's forecast of the present and future demand for cans by type of metal shows that aluminum and tin-free steel or black plate will become the predominant containers at the expense of tin plate. (Table 38) Tin plate containers will decline from 48.3 billion units in 1972 to 38.3 billion in 1980. Tin-free steel or black plate will nearly double during this period to 32.4 billion units while aluminum will triple by 1980 to 28.1 billion units.

Beverage: Steel cans used for beer accounted for 14.7 billion containers in 1972 but will decline to 14.0 billion by 1980 (as aluminum displaces steel on a percentage of total market). The steel cans will be mostly manufactured from tin-free or QAR steel with two-piece drawn and iron steel cans becoming a factor by 1976. Initially they will be manufactured from tin plate, but developing technology will permit use of QAR or black plate steel.

TABLE 38

METAL CAN DEMAND BY TYPE OF METAL
(Millions of Cans)

	1962	1972	1975	1980	1990
Tin Plate	46,662	48,300	43,600	38,300	28,700
Tin-Free Steel	--	16,400			
Black Plate	1,500	1,000	23,600	32,400	45,600
Aluminum Cans	NA	10,300	17,900	28,100	42,800
Total	48,162	76,000	85,100	98,800	117,100

Source: Midwest Research Institute.

Aluminum receives some preference for beer cans because the "taste threshold" for aluminum in the beer is higher than for iron. The trend to the two-piece cans will continue as the large breweries install their own can manufacturing lines and the can manufacturers begin producing aluminum cans to counter this move.

Tin-free or QAR steel will continue to increase its share of the soft drink markets as the three-piece soldered can lines are phased out. There will be a trend to the two-piece drawn and ironed steel can as manufacturers develop this system to compete with the welded and cemented three-piece cans of Continental Can and American Can.

There is less incentive to use aluminum in soft drink cans since few soft drink canners are large enough to install their own lines economically. Thus, as we project to 1980, aluminum will increase its share of the beverage can market from 25 percent in 1972 to 42 percent in 1980, mostly in beer cans. Tin-free or QAR steel will increase from 42 percent to 47.5 percent and tin plate will decline from 33 percent to 10.5 percent by 1980 and be completely out of beverage markets by 1990 (Table 39).

Food and general packaging: Tin plate is the preferred metal for the manufacture of food cans because the properties of tin help preserve and protect the quality of many canned foods. It is expected that tin plate will continue to be the metal for most canned foods. Many of the canners have their own can manufacturing plants producing the three-piece soldered cans and will be unlikely to invest in new technology unless significant cost savings are indicated.

TABLE 39

BEVERAGE CANS DEMAND BY TYPE OF METAL
(In billions of units)

Type Can and Use	1972	1975	1980	1990
Beer:				
Aluminum Cans	6.9	12.5	19.5	31.0
Steel Cans	14.7	14.0	14.0	13.5
Total	21.6	26.5	33.5	44.5
Soft Drink:				
Aluminum Cans	1.6	3.0	5.0	6.0
Steel Cans	14.0	16.2	19.6	24.0
Total	15.6	19.2	24.6	30.0

STEEL BEVERAGE CAN DEMAND, BY TYPE OF METAL
(In billions of units)

Type of Steel	1972	1975	1980	1990
Tin-Free Steel	15.6	20.8	27.0	37.5
Tin Plate Steel	13.1	9.4	6.6	--
Total	28.7	30.2	33.6	37.5

Source: Midwest Research Institute estimates.

Aerosol containers have historically been tin plate because of the strength needed for the high pressure contents. Continental Can has recently constructed a tin-free steel line to produce 3 million aerosol cans a year.[101/] It is expected that all of the aerosol growth will be in tin-free or QAR steel.

Other markets such as aerosols and paint are relatively small and not expected to grow much. It is anticipated that current practices of using steel cans will continue at about the same level.

STEEL CONSUMPTION IN CANS*

The manufacture of cans produces scrap from cutting and forming operations (approximately 1 percent of input weight for the body of a three-piece beverage can). There are no public data sources that accurately indicate the amount of metal consumed in the manufacture of steel cans. The American Iron and Steel Institute reports shipments of tin plate, black plate and tin-free steel for metal can manufacturing. This does not reflect changes in inventories at the can plants, which are significant, nor does it include imports which are purchased by can plants. The Department of Commerce reports shipments of steel contained in the finished cans but does not include the amount of scrap which is generated.

We have determined the amount of aluminum and steel required in can manufacturing by combining estimates for finished cans with estimated scrap rates. This results in a metal "consumption" of 6,230,000 tons of steel and 575,000 tons of aluminum in 1972 (Table 40). This is the input metal required for the years designated. Tin plate will be declining and tin-free or black plate steel will be increasing. By 1980, tin-free steels will have increased to 35 percent of all steel from 19.5 percent in 1972.

TABLE 40

CAN MANUFACTURE METAL INPUT QUANTITY
(In thousands of tons)

Type of Metal	1972	1975	1980	1990
Tin Plate	5,000	4,655	4,206	3,475
Tin-Free Steel	1,020	1,649	2,266	3,317
Black Plate	210			
Total Steel	6,230	6,304	6,472	6,792
Aluminum: cans	350	613	938	1,400
Aluminum: ends	225	225	225	225
Total All Metal	6,805	7,142	7,635	8,417

Source: Midwest Research Institute.

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* For discussion of aluminum consumption in cans, See Chapter VII.

Table 41 separates metal demand into net metal in finished cans, ends and fabricating scrap. The scrap is currently recycled through detinners for use as steel furnace scrap or copper cementation, while the finished cans eventually become post-consumer solid waste. The total steel in cans (output) will rise from 5.59 million tons in 1972 to 6.11 million tons in 1990.

TABLE 41

METAL IN FINISHED CANS AND FABRICATION SCRAP FROM CAN MAKING
(In thousands of tons)

	1972		1975		1980		1990	
	Cans & Ends[a]	Scrap[b]	Cans & Ends	Scrap	Cans & Ends	Scrap	Cans & Ends	Scrap
Tin Plate	4,473	527	4,159	496	3,755	451	3,093	382
Tin-Free Steel	930	90	1,500	149	2,050	216	3,019	298
Black Plate	187	23						
Total Steel	5,590	640	5,659	645	5,805	667	6,112	680
Aluminum Cans and Ends	403	172	587	251	813	350	1,137	448
Total all metals	5,993	812	6,246	896	6,618	1,017	7,249	1,128

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[a] Total metal finished can at 10.3 percent scrap rate for steel cans and 30 percent for aluminum.

[b] Scrap from can manufacture recycled to detinners or steel scrap dealers; aluminum to remelt operations.

Source: Midwest Research Institute estimates.

Tin-free steel, black plate, QAR: An estimated 1.02 million tons of tin-free steel and an additional 210,000 tons of black plate were used to manufacture cans in 1972. The tin-free steel finds its greatest use in the manufacture of beverage cans in the Conoweld® and Miraseam® processes. QAR steel, which is tin-free steel without the chrome coating, and black plate steel are being evaluated for use in beverages. We project that tin-free steel with the chrome coating will begin to decline after 1975 as QAR becomes accepted for beverage manufacturing. The two-piece drawn and ironed steel can manufactured from black plate or QAR steel will be commercial technology after 1975. Prior to 1975, these cans will be made of tin plate, but the industry will convert to black plate as the technology is developed. Thus, by 1980 tinless plated steel will increase to 2.27 million tons.

Using the scrap rates given in Table 41, it was estimated that net use in cans for tin-free steel was 930,000 tons and for black plate 187,000 tons in 1972. This will increase to 2.05 million tons of tin-free steel by 1980 and 3.0 million tons in 1990 (Table 41).

Tin plate: Electrolytic tin plate estimated at 5 million tons in 1972 will decline to 4.2 million tons by 1980. Tin plate is and will continue to be the largest volume steel used in can manufacturing. Although it will be completely out of beverage markets by 1990, it will remain as the preferred metal for foods. Scrap rates were estimated at 8 percent for beverage cans and 11 percent for all other uses. Net tin plate used in finished cans (exclusive of scrap) was estimated at 4.47 million tons in 1972 and will decline to 3.1 million tons by 1990 (Table 41).

FERROUS METAL WASTE GENERATION BY SOURCE

Waste Generation - Steel Cans

Metal cans are used to package consumer, commercial, institutional and industrial products. They are manufactured, filled and shipped to a retailer. The consumer purchases the container, uses the product and discards it to the solid waste stream. Almost all cans are discarded within a year after manufacture, and in many cases, it may be immediately after purchase or within a matter of days.

It is possible that some food products, paint cans or other items may be in inventory at the producer or consumer level or are diverted for use as a general purpose container in the home for more than a year. This quantity is assumed to be small and the net withdrawal from the waste stream each year would be insignificant so we have not considered it to be a factor in waste generation.

Assuming that 100 percent of the metal cans appear as solid waste and litter within 1 year after they are purchased or manufactured, the resulting waste generation will be 5.59 million tons of steel. This is projected to increase to 6.11 million tons of steel by 1980.

Steel cans will appear as waste from households and apartments as a result of their use by the consumer and from commercial and institutional establishments as the result of over-the-counter sales of beverages; purchase of food by restaurants and institutions; vending machine use; and use of oil cans by service stations. Industrial container wastes are primarily cans from vending machines and industrial chemicals and cleaners.

Waste generation for cans by source by various end uses was estimated (Table 42). About 83 percent of cans appeared as household waste, 16 percent were generated from commercial and institutional sources and 1 percent from industrial waste in 1972.

TABLE 42

STEEL CANS, WASTE GENERATED BY SOURCE, 1972
(In thousand tons and percent)

	Household		Commercial/ Institutional		Industrial		Total
	Tons	Percent	Tons	Percent	Tons	Percent	Tons
Food	2,576	83	528	17			3,104
Beer	713	90	79	10			792
Soft Drink	595	80	149	20			744
Aerosol	225	90	20	8	5	2	250
General Packaging	525	75	140	20	35	5	700
Total	4,634	82.9	916	16.4	40	0.7	5,590

Source: Midwest Research Institute.

Food: An estimated 17 percent of the canned goods for food are used in commercial and institutional establishments which purchase large size cans. Although the trend to eating out continues to increase its share of the food dollar (21.5 percent in 1972),[102/] much of this is in fast food franchises that use fewer cans because of the narrow product line. Therefore, we do not anticipate any change in this ratio in the future.

Beer: A study by American Can gives estimates that in 1967, 80 percent of the packaged beer (cans and bottles) was sold off-premise and the balance on-premise through restaurants, taverns and other establishments licensed to sell the product.[95/] On-premise sales amounted to 1.2 billion cans equivalent to 9 percent of all beer cans produced in that year and while the total in 1958 was only 800 million cans, the ratio of beer cans sold on-premise had declined from 10.4 percent.

With the addition of the beer purchased in cans by various institutions, we have estimated that 10 percent of all beer is consumed from cans in commercial and institutional establishments and 90 percent consumed in the home. This ratio should not change during the next 2 decades with decreasing use at institutions being offset by some growth in taverns.

Soft drinks: It is estimated that 20 percent of the canned soft drinks are sold through commercial establishments and institutions. A recent survey indicated that 2.8 billion soft drink cans were sold through vending machines in 1972.[97/] This is equivalent to 17.5 percent of all canned soft drinks. Additional sales of canned drinks which are sold over the counter by restaurants and taverns will increase the volume through commercial and institutional establishments to 20 percent of all soft drinks in cans. Most of the vended products in industrial plants are returnable glass and very little is in cans.

It is projected that soft drinks in cans sold through vending machines will amount to 3.9 billion units in 1980 or 16 percent of the soft drink can market.[97/] The share of cans in commercial and institutional establishments is estimated at 19 percent in that year.

Aerosols: Nearly all aerosols are consumer products. We have estimated this market at 90 percent household, 8 percent commercial-institutional and 2 percent industrial. Personal product aerosols are used in beauty parlors and by office workers. Cleaning and polishing preparations are used to clean institutions and offices. A small amount of aerosols are classed as industrial products and include oils, greases, spray paints and cleaners. There are no trends in this area that would change the ratios for 1972 in the future.

General packaging: These products are estimated at 75 percent household, 20 percent commercial-institutional and 5 percent industrial. About 50 percent of the oil and antifreeze cans are sold through retail outlets to the consumer and the balance through gas stations. Paint cans are used largely by consumers; industrial firms purchase paint in larger sized pails. This ratio is not anticipated to change.

Steel Cans in Litter

Numerous litter surveys conducted by groups throughout the country have identified the beverage container as the principal metal component of litter. The only comprehensive study concerning litter was published by Research Triangle Institute in 1972.[81/] This study estimated that 1,637 million cans were discarded as litter in 1969. This is equivalent to 2.5 percent of all metal cans produced and 5.7 percent of all beverage cans. Assuming that about 50 percent of the litter is recovered by maintenance crews and other litter pickups, we estimate that unrecovered litter is about 3 percent of all beverage cans. This would result in a litter component of about 46,000 tons of steel in 1972.

With increased public awareness of litter and laws being enacted which tax nonreturnable beverage containers, it is likely that the litter component will decline over the next 2 decades. Assuming that 2 percent of the beverage containers produced each year will remain on the ground as litter, this will result in a litter factor of 32,000 tons in 1975, 36,000 tons in 1980 and 40,000 tons in 1990.

NON-CAN FERROUS METAL IN MUNICIPAL WASTE

In addition to ferrous metal cans there are a variety of other ferrous metal products found in municipal waste. This includes small appliances, tools, nails, hardware, wire, toys, paper clips, etc. Thus, the ferrous metal cans are almost always associated with other metal products in waste. An example of a representative compositional analysis of a magnetic waste fraction separated from mixed waste is given in Table 43.

TABLE 43

MAGNETIC SEPARATION ANALYSIS FROM MIXED WASTE

Classification		Weight Percent	Ferrous Only
Nonmetallics		5	
Ferrous Materials (other than cans)		38	40
Can Metal		57	60a/
Iron	53.5		
Aluminum	1.7		
Lead	0.5		
Tin	0.2		
Organic Coatings	1.1		
Total		100	100

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a/ Ferrous metal is 94 percent of can metal.
Source: "Technology Review," May 1972, p. 40.

Thus, can metal in solid waste is presently about 60 percent of total ferrous metals. Because ferrous metal cans are forecast to grow very slowly to 1990, we believe that the can fraction of total ferrous metals in waste will decline steadily because other ferrous metal products will have higher growth rates than cans. As a consequence, we have forecast that non-can ferrous metals will increase from 40 percent in 1972 to 43 percent in 1975; to 48 percent in 1980 and 55 percent 1990.

TOTAL FERROUS METAL WASTE GENERATION, 1972 TO 1990

Using the previous estimates of non-can wastes, we can calculate the total ferrous metals in mixed municipal waste from our forecasts of can demand. This is incorporated in Table 44, which shows ferrous metals in municipal waste from all sources.

TABLE 44

FERROUS METAL IN MIXED MUNICIPAL WASTE, 1972 TO 1990
(In thousand tons)

Source and Type	1972	1975	1980	1990
Cans:				
Households	4,604	4,650	4,770	5,020
Commercial/ Institutional	916	935	958	1,010
Industrial	40	40	42	45
Total cans	5,560	5,625	5,770	6,075
Other Ferrous Metal	3,705	4,245	5,315	7,425
Total Ferrous Metal	9,265	9,870	11,085	13,500
Litter (unrecovered)	30	32	36	40
Percent cans (excluding litter)	60	57	52	45

Source: Midwest Research Institute

FERROUS METAL RECOVERABLE FROM MUNICIPAL WASTE

Ferrous metal recoverable from municipal waste was determined by assuming that the population base and density of SMSA's was the minimum from which significant recovery could be practiced. The basis of recoverable tonnage was developed in Chapter V. Using the previously calculated allocation of household, commercial/institutional and industrial waste to SMSA's, the recoverable ferrous metal was calculated. In this case, noncan waste was allocated to the waste sources in the same ratios as can waste (see Table 45).

TABLE 45

FERROUS METAL WASTE GENERATION, SMSA'S 1972-1990
(In thousand tons)

Waste Source	1972	1975	1980	1990
Household	5,260	5,655	6,460	9,815
Commercial and Institutional	1,133	1,225	1,400	1,770
Industrial	42	45	50	65
Total[a]	6,435	6,925	7,910	11,650

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a/ Excludes litter.

Source: Midwest Research Institute.

FERROUS METAL RECYCLING FORECASTS, 1972 TO 1990

Current Steel Can Recycling Practices

The steel industry has always been the largest recycler of scrap (on a tonnage basis) in the country, consuming close to 85 million tons of scrap in 1972 for the manufacture of steel and foundry products. However, the source of the steel is 60 percent home scrap (scrap generated in the mill), 16 percent purchased prompt industrial scrap (steel purchased from fabrication plants), and 24 percent obsolete scrap (scrap available from obsolescence, e.g., equipment, automobiles, etc.).103/

The only other significant use for steel scrap outside of the steel industry is for copper precipitation which consumes 510,000 tons per year (principally can scrap and cans from solid waste). Shipments of steel for the manufacture of metal cans in 1972 was previously estimated at 6.23 million tons of which an estimated 0.71 million tons (11.3 percent) were recycled. The greatest amount (0.64 million tons) was can plant scrap from the can manufacturing process. This was recycled through detinners to the steel and copper industry after the tin was removed. The balance was from post-consumer waste recovery (Table 46).

TABLE 46

STEEL CAN RECYCLING, 1972
(In Thousand Tons)

	Post-Consumer Waste[a]	Can Plant Scrap[b]	Total
Copper Precipitation	50	640	705
Detinning	4		
Steel Manufacture	11		
Ferroalloys	3	—	3
Total	68	640	708

Source: a/ Office of Solid Waste Management Programs, EPA.
b/ Midwest Research Institute estimates.

In 1972, approximately 50,000 tons of post-consumer scrap was shipped to the copper industry in the West (Montana, Utah, Arizona). The source of the scrap included incinerator residue from Chicago, Illinois, and Amarillo, Texas; post-consumer cans collected from local scavengers and private waste haulers located near shredding plants; and from selected cities that recover steel by magnetic separation of their municipal solid waste. The copper industry requires that the scrap be shredded and have a high surface to weight ratio. Most of the post-consumer scrap is shredded by Proler Steel in Houston, and Los Angeles By-Products Company in San Francisco, California, who ship directly to the copper industry.

Approximately 15,000 tons of post-consumer cans are recycled as the result of voluntary collections. These cans were used by the steel mills (11,000 tons) and detinners (4,000 tons).[103] This tonnage is equivalent to about 300 million beverage cans which is much less than the 1.2 billion aluminum cans collected in 1972. The small amount of steel can collection is a result of the economics. Aluminum companies can pay $0.10 per pound or more for all aluminum cans while steel cans command less than $0.01 per pound.*

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* Recently the price has gone up to $0.15 per pound.

The recovery of steel from post-consumer steel cans in 1972 is assumed to be all from within the SMSA's since it was from incinerator residue, volunteer collections, and magnetic separation plants. The available steel can waste in these areas in 1972 was 3.860 million tons. The recovery of 68,000 tons results in a recycling rate of only 1.8 percent of the available steel can post-consumer waste in 1972. This will leave a potential for resource recovery of 3.79 million tons.

It is apparent that if any significant recycling of metal cans is to be achieved, it must come from resource recovery systems in major metropolitan areas. Volunteer collections will be limited to concerned environmental groups since the hand segregation costs far outweigh the price received for the steel cans, and no growth beyond today's level of recovery is projected for volunteer collections.

Recovery of Ferrous Metals for Recycling From Mixed Municipal Wastes

The recovery of steel cans and other ferrous metals from municipal waste is dependent upon the technology to recover and upgrade the steel, the economics of recovery, the quality of the recovered steel, and the development of markets for the steel. An unresolved question concerning ferrous metal recovery is whether the market will develop before the recovery systems are established or whether incentives will be needed to stimulate new uses for the recovered ferrous fraction.

The technology for recovering ferrous metals from mixed municipal wastes is well developed. This can be accomplished by magnetic separation of shredded municipal waste or by incineration of the total refuse followed by separation of the metal fraction from the incinerated waste. The first system is most likely to be the favored technology.

Magnetic separation: The most promising method for recovery of steel metal cans is magnetic separation of ferrous metal from shredded municipal waste. This technology has been proven to be successful and there are several systems throughout the country recovering cans by this method (e.g., St. Louis, Missouri; Houston, Texas; and Madison, Wisconsin).

Recovery of the ferrous materials is a relatively simple operation. Most of the processes are dry systems where the incoming solid waste passes through a shredder, such as a hammermill, to reduce the material in size. The waste is then conveyed to a magnetic separator which removes the ferrous fraction by electromagnetism. This fraction is a relatively dirty material and must be upgraded through air classification, washing, and possibly incineration to remove organic material and a secondary shredding (or densification) for changing to dust or steel fumes. In St. Louis, the air classification step takes place after shredding followed by magnetic separation and densification (these steps produce a clean scrap). Some more sophisticated processes plan to separate heavier ferrous fractions from the light can fraction so a relatively pure can metal will be obtained.

Although most of the processes are dry, the Franklin, Ohio, experimental plant uses a wet system. The incoming waste is slurried in a water system and reduced in size in a hydropulper. Future plans call for removal of the heavier fraction from the hydropulper before magnetically separating the lighter can fraction.

Ferrous metals can be recovered from municipal waste with existing technology. Economics will probably be the limiting factors in the future recovery of ferrous metal since shredding is the largest portion of the cost of the recovery of the ferrous fraction. Thus, recovery of ferrous metals from mixed wastes will not occur unless a municipality decides to reduce their waste in size by shredding. Shredding will be practiced in communities where landfill capacity is limited or where resource recovery systems are installed. Once these decisions are made, the cost of magnetic separation is incrementally very low.

The recovery of ferrous metals is a simple, relatively low-cost operation once the decision has been made to shred the waste. The quality of the steel from simple magnetic separation is too low for use in many markets without some method of upgrading. However, with densification to improve quality, the steel may be used for copper cementation, steel manufacture by addition to the blast, basic oxygen or electric steel furnaces or for ferroalloy and iron foundry production.

Incinerator residue recovery: The other method for recovering metal cans is incinerator waste recovery presently being practiced in Amarillo, Texas; Atlanta, Georgia; Chicago, Illinois; Melrose Park, Illinois; Stickney, Illinois; and Tampa, Florida.[103/] The metal waste is separated and shipped to commercial shredders for sale to the copper industry or sold directly for use in ferroalloy production.

The composition of incinerated waste will vary with temperatures of the incinerator. At temperatures from 1000°F to 1400°F, the characteristics of ferrous material is only slightly altered. Below 1400°, aluminum may be oxidized, but generally is not melted and separated from the ferrous fraction.[73/] At temperatures of 1400°F to 2000°F, practically all the aluminum is melted off and/or oxidized. Some tin is removed from the tin plate by oxidation or alloying with other nonferrous metals, but most of the tin is absorbed into the steel and cannot be removed after this occurs. Copper may also be absorbed into the steel. If the temperature in the incinerator reaches 3000°F, there is complete alloying of all the metals present and any glass fuses to form a slag-like mixture over the molten metal. It is difficult to process this slag further to remove any metals.

Most of the nation's waste incinerators operate below 2000°F and the typical residue contains 1/2 to 1 percent copper and about a quarter of a percent tin. These levels are too high for satisfactory use in the manufacture of most steels. Copper increases the hardness and the tin causes problems during deep drawing of the steel.

Since the material cannot be detinned or readily used in steel manufacture, its major outlet has been in copper precipitation where the copper is not a problem; in fact it adds value to the recovery process. The demand for incinerated scrap is greater than the availability, west of the Mississippi, but most incinerators are located east of the Mississippi, beyond the economic shipping range of the western copper mills. A small amount of incinerator waste is used in the production of ferroalloys. However, only one company is known to be using it.[103]

A demonstration grant for the Bureau of Mines Incinerator Residue Recovery Process has been established to construct a plant in Lowell, Massachusetts, which will recover incinerated ferrous metals.[83] This system will use a series of screens and shredders to segregate the metals from glass, paper, and other nonmetals before passing them through a magnetic separator to remove the iron fraction. The plant is not yet in operation.

It is doubtful that incinerator residue will increase much in importance, partly because conventional incineration will not be used on a higher percent of waste than it is now. Incinerator residue is high in copper and tin, which limits its use to copper precipitation and possibly ferroalloy manufacture. It is also one of the highest cost municipal waste processing options available today and many incinerators are closing down because they cannot conform to federal and state air pollution regulations. The future supply of incinerator residue will be the limiting factor on its use, rather than the development of markets.

RECYCLING OPTIONS FOR STEEL RECOVERED FROM MIXED WASTE*

Copper precipitation: The copper industry presently consumes over 500,000 tons per year of light gauge ferrous scrap. The current market is supplied by 260,000 tons of detinned steel, 50,000 tons of post-consumer can scrap; and 190,000 tons of other steel scrap.

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* A discussion of trends in the demand for ferrous scrap in iron and steel production is included in Appendix A.

Demand is projected to increase to over 900,000 tons per year by the early 1980's.[19]* Because of the projected decline in tin plate used to manufacture metal cans, the can plant scrap available to detinners will decline in the future. Thus, the additional 400,000-ton increase during the next decade will have to come from recovered municipal waste or from other steel sources. The most logical source would be recovered can scrap from municipal waste since this material has a broad surface area and a low density which is desired by the copper industry. By the middle 1980's, an additional 400,000-ton market in copper precipitation will exist for waste from municipal recovery systems.

Steel mills: The largest potential market for recovered steel from municipal waste would be as scrap in the steel industry--as a substitute for iron ore in the blast furnace or in the basic oxygen and electric furnaces. It is estimated that in 1972, 34 million tons of iron and steel scrap were purchased by the steel industry for use in the manufacture of steel. If all post-consumer can scrap available in the SMSA's in 1972 were recovered, it would only represent 11.4 percent of the scrap now used by the industry. Experiments by the steel industry have shown that the fraction available from a single magnetic separation needs further processing before it can be used in the steel mill. The density is too low and must be increased from 40 pounds per cubic foot to 75 pounds per cubic foot, which can be done by a densifying shredder.

At the present time, none of the steel mills are using recovered municipal can scrap on a continuous basis since it has not been available in commercial quantities. The St. Louis resource recovery plant ships densified ferrous scrap to the Granite City Steel Company (a division of National Steel), where it is being used in the blast furnace. (Milling of the waste after magnetic separation increases the density of steel from 40 pounds per cubic foot to 75 pounds per cubic foot and separates an aluminum-rich fraction which may be processed to recover aluminum.) National Steel is feeding different percentages of scrap metal to the basic oxygen furnace to determine its impact on the finished steel. At the time of this report, no test results had been made public by the steel mill.

The American Iron and Steel Institute Committee of Tin Mill Products Producers has stated that recycled cans could make up about 5 percent of the scrap charge to the basic oxygen furnace.[76] Since the scrap charge represents about 30 percent of the total charge, this will be equivalent to 1.5 percent of the total steel produced or a potential demand of 3 million tons per year. It is also possible to replace up to 5 percent of the iron ore in the blast furnace with scrap steel cans. However, as previously stated, the recovery limits for cans are about 3.9 million tons, of which about 80 percent is tin plate. Thus, despite the periodic proclamations from the steel industry that tin "contamination" of steel could be a problem, it is doubtful if this is a real technical limitation to can recycling. The remaining non-can steel, which is not tin plated, could be used without technical limitations.

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* New techniques in copper precipitation are being tried which may eliminate the need for scrap steel also.

Ferroalloys: Another potential market for ferrous scrap is for the production of ferroalloys. Presently, Union Carbide at Sheffield, Alabama, is using incinerator scrap from Atlanta, Georgia, for producing ferroalloys.[103] They have used this scrap for 10 percent of their iron requirements and found that no problems exist. Since this industry uses close to 500,000 tons per year of iron based ore, this represents a potential market of 50,000 tons per year, if the 10 percent level is the limit.

Foundries: The foundry industry uses approximately 8.4 million tons of iron scrap and 6.6 million tons of steel scrap per year. This represents a significant potential for the use of recovered municipal metal scrap. These foundries are dispersed throughout the country and should be within economic shipping distance of potential resource recovery systems. Unfortunately, cast iron is much more sensitive to certain alloying elements than steel and so great care must be exercised in controlling impurities. Experimental data on the use of recycled can scrap in production of cast iron or steel are not available. The American Iron and Steel Institute has contracted with Professor John Wallace of Case Western Reserve to conduct studies on the use of metal cans in gray and ductile foundry applications. Atlas and Phoenix Foundry in San Francisco have agreed to assist in this study by conducting production melting experiments. Although it is a possible market, it will remain speculative until experiments are completed. In addition, foundry output is not a growth sector of the ferrous metals industries.

Detinning: Steel cans could possibly be recycled by processing them through detinning operations to remove the tin and lead. This would produce a good grade of scrap steel for recycling to the steel mills. Commercial detinners process close to 700,000 tons of steel per year, removing the tin and selling the clean steel in the form of No. 1 bundles at the going price. The tin is recovered and sold for about $4,000 per ton.[103]

Detinners shred the material and remove the tin by addition of hot caustic soda and sodium nitrite. The chemical reaction forms sodium stannate which is removed and electrolyzed to recover tin. The detinner is limited by the economics of the process and the price of steel and tin. The price of the steel scrap is usually based on No. 1 scrap and the price of tin is fixed by the imported tin price. The detinning costs besides equipment and labor are primarily the chemicals required to remove the tin. Ideally the detinner would like a scrap that has a good surface area and is high in tin. Impurities in the material increases the cost of the chemicals and separation of the tin becomes more difficult.

One of the biggest problems limiting the use of recovered cans is the aluminum lids from beverage cans. Caustic soda attacks aluminum preferentially to tin, producing aluminum oxide which has no value. It also evolves hydrogen which can be explosive if aluminum is present in high concentrations. Aluminum substantially increases the cost and makes the detinning process less attractive. If steel cans become available in larger quantities, technology may be developed so that the economics of detinning are much more attractive. At the present time, it is a marginal outlet for recovered steel cans, especially post-consumer scrap.

Conclusions

There are a number of conclusions that can be drawn concerning the future of ferrous metal and steel can recycling:

1. The technology exists for recovering a relatively high quality ferrous fraction from municipal waste recovery systems. Conventional shredding and magnetic separation equipment will produce a fraction containing approximately 90 percent iron. Further processing such as low temperature incineration to remove organics, air separation to separate heavier metals, secondary shredding to increase density and a final magnetic separation to remove aluminum will produce a good grade of steel scrap.

2. Magnetic separation of iron from municipal wastes will be practiced in municipalities that install a system for size reduction of their wastes prior to incineration, energy recovery, materials recovery or landfill. Once the decision has been made to further process the waste, magnetic separation can be added for a low incremental cost. Additional processing steps, e.g., air classification and densification to increase the quality of the steel will increase these costs somewhat.

3. Additional upgrading will be necessary to penetrate potential markets. Copper precipitation could potentially use an additional 400,000 tons per year during the next decade. The recovered scrap will require low temperature incineration to remove organics and nonmetallics after magnetic separation.

Additional shredding and densifying followed by a second magnetic separation should remove aluminum and make the steel competitive with other scrap for steel manufacture. If 5 percent of the scrap charge could be metal cans, a potential market of over 3 million tons per year would develop.

4. Ferroalloy and iron and steel foundry markets are speculative and will require additional evaluations before they can be considered potential markets. Detinning of the waste does not appear to be economically feasible under present conditions. If the price of tin and No. 1 scrap increase significantly (as scrap prices did in 1973), this could be a potential market in the future.

5. The recovery of ferrous metal from municipal waste recovery systems will develop slowly and potential markets will depend upon the success of demonstration projects such as St. Louis to determine the effect the cans will have on steel manufacturing. However, ferrous metal recovery is expected to keep pace with the installation of centralized resource recovery systems.

RECOVERY FORECASTS FOR FERROUS METALS

Ferrous metals will be recovered via four methods in the future. These are: volunteer collections; incinerator residue recovery; magnetic separation at transfer stations or "front end" recovery systems; centralized waste-processing systems (usually for energy recovery).

The installation of centralized waste-processing systems will be justified on the basis of all recoverable materials but the determining factor will be the use of the organic fraction in waste for energy recovery. This was discussed in Chapters II and III. For the most part, once a centralized waste-processing system is installed, then magnetic separation can be carried out at relatively low incremental cost and the metal can be absorbed by the steel industry and exports. The waste profile for ferrous metals recovery is summarized in Table 47. Recovery will rise from 115,000 tons in 1972 to 2.2 million tons in 1990 at a mechanical recovery efficiency of 85 percent.*

Recovery of voluntary collection centers will not rise above the 15,000 tons per year current rate. There is little incentive to recover steel cans in comparison to aluminum and waste paper.

Magnetic separation at transfer stations, landfills and incinerators will account for some additional recovery. This will require the installation of "front end" systems utilizing shredding/magnetic separation. In addition, incinerator residue systems may yield up to 50,000 to 80,000 tons per year. We estimate that 14 facilities will be shredding and recovering steel in 1975; 18 by 1980; 21 by 185; and 23 by 1990. Each will process about 100,000 tons/year each of solid waste. Thus, recovery will be based upon ferrous metal content of the waste and recovery efficiency. This will result in recovery of 83,000 tons in 1975 (100,000 tons x 14 systems x 0.071 steel content x 0.85 recovery efficiency). Recovery will be 105,000 tons in 1980; 125,000 tons in 1985; and 135,000 tons in 1990 (Table 48).

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* MRI estimates that the mechanical efficiency of ferrous metal systems will be in the order of 85 percent after all upgrading steps have taken place.

TABLE 47

RECOVERY OF FERROUS METALS IN CENTRALIZED PROCESSING SYSTEMS FROM MIXED MUNICIPAL WASTE, 1972 TO 1990

(In thousand tons)

Category	1972	1975	1980	1985	1990
Total solid waste generated	130,000	140,000	160,000	180,000	200,000
Ferrous metal in mixed waste[a]	9,265	9,870	11,075	12,500	13,500
Percent ferrous metal[a]	7.1	7.1	6.9	6.9	6.8
Total waste processed in centralized recovery systems	Neg.	2,100	6,600	24,000	48,600
Ferrous metal content	Neg.	150	415	1,705	3,315
Ferrous metal recovery at 0.85 recovery efficiency	Neg.	127	395	1,450	2,815
Number of recovery systems operating	0	5	12	32	60

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[a] Excludes ferrous metal in bulky appliances.

Source: Midwest Research Institute.

TABLE 48

SUMMARY OF FERROUS METAL RECOVERY FROM MIXED MUNICIPAL WASTE, 1972 TO 1990

(In thousand tons and percent)

Type of Recovery	1972	1975	1980	1985	1990
Volunteer collection	15	15	15	15	15
Incinerator residue	50(est.)	55	60	65	70
Magnetic separation	3(est.)	83	105	125	135
Centralized recovery systems	0	127	395	1,450	2,815
Total recovery	68	280	575	1,655	3,035
Steel cans only[a]	47	165	305	760	1,365
Total recovery as a percent of:					
Total ferrous waste	0.7	2.8	5.2	13.2	22.5
Ferrous waste in SMSA's	1.1	4.0	7.3	17.6	26.0

Source: Midwest Research Institute

[a] Based on percentages in Table 44 applied to incinerator, magnetic, and centralized; volunteer considered to be 100 percent cans.

In summary, total recovery of ferrous metals from municipal wastes were 68,000 tons in 1972, and will rise to 575,000 tons in 1980; and 3.0 million tons in 1990. This is 0.7 percent of ferrous metals generated in 1972, rising to 22.5 percent in 1990. We do not distinguish steel can recovery from all ferrous metals. However, can recovery will be proportional to the percentage in ferrous waste or 60 percent in 1972, declining to 45 percent in 1990.

These results show that ferrous metal net tonnage in post-consumer waste will increase from 9.2 million tons in 1972 to 10.8 million tons in 1985, after which it will decline slightly.

We believe that markets will be developed readily for the forecast quantities of recovered steel from municipal waste systems (3.0 million tons in 1990). The major markets will be scrap for use in steel furnaces and export tonnage (either directly or "freeing up" other steel scrap for export) with copper cementation accounting for about 0.4 million tons of the total. Thus, it can be seen that at this level of recycling in 1990, the amount of steel scrap returning to the steel industry will be well below the capability of the industry to absorb scrap of the quality to be expected from resource recovery systems.

RECOVERY FORECASTS FOR STEEL IN MAJOR APPLIANCES TO 1990

Production, Use and Discard Cycles for Appliances

There are presently more than 350 million major appliances in use in U.S. households, including clothes dryers, washing machines, ranges, refrigerators, water heaters, room air conditioners, dehumidifiers, garbage disposers, and freezers. Of these, the first five account for more than 75 percent of the total steel used in appliances.

A high proportion of new appliance sales are as replacements for discarded appliances. For all but clothes dryers, annual discards are presently averaging more than two-thirds of the annual new sales. Future appliance discards, then, can be projected with reasonable accuracy largely on the basis of past appliance sales. Table 49 shows the estimated service life associated with each of the five major appliances, as developed from three independent sources: Data published in Institute of Scrap Iron and Steel Report No. EPA-SW-45D-72, "Identification of Opportunities for Increased Recycling of Ferrous Solid Wastes;" an MRI survey of appliance owners, and; an analysis of appliance retirement histories from 1950 to 1970, based on data published in the Statistical Abstract of the United States.

TABLE 49

ESTIMATED SERVICE LIFE OF MAJOR APPLIANCES
(In years)

Appliance	Service Life Until Discard (Years) Low	High	Estimated	Estimated Retirement Rate (%)
Clothes Dryer	9	30	15	6.7
Washing Machine	8	16	10	10.0
Range	18	20	20	5.0
Refrigerator	13	20	17	5.9
Water Heater	8	13	10	10.0

Source: Midwest Research Institute. Estimates based on ISIS data, appliance owner survey, and appliance retirement histories.

Projected sales and discards of new major appliances and the total number of each appliance expected to be in service over the 1970 to 1990 period are summarized in Tables 50 through 54. In developing these estimates, the total number of appliances in use was projected based on historical data, and the number of discarded appliances were calculated by assuming the appropriate service life for each (as given in Table 49). For example, it was assumed that all clothes dryers installed in 1970 would be discarded in 1985.

TABLE 50

CLOTHES DRYERS IN SERVICE, SOLD AND DISCARDED, 1970 TO 1990
(In million units)

Year	Number in Service on January 1	New Sales During Year	Number Retired During Year	Number in Service on December 31
1972	29.5	3.5	1.3	31.7
1975	36.3	3.7	1.3	38.7
1980	49.1	5.1	2.1	52.1
1985	64.7	6.4	3.0	68.1
1990	82.9	7.5	3.7	86.7

Source: Midwest Research Institute estimates based upon ISIS Report EPA-SW-450-72 and Statistical Abstract of the U.S.

TABLE 51

WASHING MACHINES IN SERVICE, SOLD AND DISCARDED, 1970 TO 1990
(In million units)

Year	Number in Service on January 1	New Sales During Year	Number Retired During Year	Number in Service on December 31
1972	61.2	5.7	3.8	63.1
1975	66.9	6.3	4.4	68.8
1980	76.6	6.2	4.1	78.7
1985	86.8	8.3	6.3	88.8
1990	97.0	8.2	6.2	99.0

Source: Midwest Research Institute estimates based upon ISIS Report EPA-SW-45D-72 and Statistical Abstract of the U.S.

TABLE 52

RANGES IN SERVICE, SOLD AND DISCARDED, 1970 TO 1990

(In million units)

Year	Number in Service on January 1	New Sales During Year	Number Retired During Year	Number in Service on December 31
1972	65.5	4.9	3.2	67.0
1975	70.1	5.5	3.9	71.7
1980	78.0	5.1	3.3	79.8
1985	87.1	6.2	4.3	89.0
1990	97.0	6.5	4.5	99.0

Source: Midwest Research Institute estimates based upon ISIS Report EPA-SW-45D-72 and Statistical Abstract of the U.S.

TABLE 53

REFRIGERATORS IN SERVICE, SOLD AND DISCARDED, 1970 TO 1990

(In million units)

Year	Number in Service on January 1	New Sales During Year	Number Retired During Year	Number in Service on December 31
1972	65.4	5.7	4.2	66.9
1975	70.0	4.7	3.1	71.6
1980	78.0	5.9	4.1	79.8
1985	87.1	7.1	5.2	89.0
1990	97.0	7.2	5.2	99.0

Source: Midwest Research Institute estimates based upon ISIS Report EOA-SW-45D-72 and Statistical Abstract of the U.S.

TABLE 54

WATER HEATERS IN SERVICE, SOLD AND DISCARDED, 1970 TO 1990

(In million units)

Year	Number in Service on January 1	New Sales During Year	Number Retired During Year	Number in Service on December 31
1972	55.5	5.8	3.8	57.5
1975	61.7	5.8	3.7	63.8
1980	72.5	7.0	4.5	75.0
1985	84.5	8.3	5.8	87.0
1990	97.0	9.4	7.0	99.4

Source: Midwest Research Institute estimates based upon ISIS Report EPA-SW-45D-72 and Statistical Abstract of the U.S.

The methodology used in estimating the amount of steel available in discarded major household appliances over the 1970-1990 period consisted of eight steps, as follows:

1. The five major appliances which comprise more than 75 percent of total steel used in appliances were selected: clothes dryers, washing machines, ranges, refrigerators, and water heaters.

2. The average life of each appliance was estimated, based on: (a) data published in ISIS Report No. EPA-SW-45D-72, "Identification of Opportunities for Increased Recycling of Ferrous Solid Wastes;" (b) a survey of MRI staff personnel; and (c) an analysis of appliance retirement histories from 1950-1970, based on data published in Statistical Abstract of the U.S.

3. The steel content of each appliance was estimated, using average appliance weights from the current Sears catalog and the average steel content reported in the ISIS report cited previously.

4. Annual data on the number of appliances in service and appliance sales during the 1950-1970 period was compiled from the Statistical Abstract of the U.S.

5. The number of appliances in service was projected by years for the 1970-1990 period, based on household saturation rates and extrapolations of 1950-1970 data.

6. The number of each type of appliance to be discarded by years was estimated, assuming that discards for a given year consist of those appliances installed X years previously, where X is the estimated appliance life.

7. The total quantity of discarded steel available in each of the five appliances was estimated from the number discarded and the steel content per appliance.

8. An additional 30 percent was included to allow for other appliances not considered separately (air conditioners, freezers, dishwashers, etc.). This 30 percent was derived by estimate of the proportion of metal in the appliances not included in the calculations of steps one to seven.

Waste generation from appliance discards: The estimated weight and steel content of the five major appliances is shown in Table 55. Applying these factors to the number of units discarded (from Tables 50 through 54) gives the total quantity of steel available in the discarded appliances, as shown in Table 56. By 1990, there will be just over 2 million tons of steel discarded in the form of the five major appliances; adding 30 percent to this total to reflect the steel available in other major appliances gives a total of 2.7 million tons in 1990, nearly double the 1970 amount.

Appliance waste generation by source: Commercial counterparts of these household appliances have little effect on the overall discard picture, with the production of commercial units amounting to only about 5 percent of the volume of household appliances.

Appliances such as washers, dryers, stoves, etc., are used almost exclusively in private homes. When an appliance is retired from service by an owner, it follows one of four routes: (1) it is traded in on a new one and the old one is hauled to the retail dealer's store for discard; (2) it is traded to a dealer who reconditions it and sells it to someone else; (3) it is discarded directly from the home; and (4) it is donated to a charitable group that sells it to someone else. Those appliances used in commercial establishments follow the same disposal routes. Thus, while the appliance is a household use items, they are not predominantly discarded from the home (except where they have no trade-in value whatsoever or a dealer will not remove them because another used appliance is purchased by the buyer).

It is not known on a national basis what the actual discard cycle is. We estimate that about 65 percent of the appliances are discarded from commercial/institutional establishments; about 33 percent are discarded from the home as a part of bulky trash pickup service; and 2 percent are in

TABLE 55

STEEL CONTENT OF MAJOR APPLIANCES

(In pounds and percent)

Appliance	Number of Models a/	Shipping Weight (lb) a/			Average Appliance Weight b/	Estimated Steel Content c/ (%)	Average Steel Content (lb)
		Low	High	Average			
Clothes Dryer	17	106	162	142	128	91	116
Washing Machine	10	205	252	229	206	83	171
Range	26	150	300	218	196	89	174
Refrigerator	14	126	350	289	260	80	208
Water Heater	25	96	224	151	136	80	109

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a/ Sears Catalog, Spring-Summer 1973.

b/ Estimated at 90 percent of shipping weight.

c/ "Identification of Opportunity for Increased Recycling of Ferrous Solid Waste," Table IV-23, p. 110. ISIS Report EPA-SW-45D-72. No change in steel content over time was estimated.

Source: Midwest Research Institute; Sears Roebuck Catalog, ISIS Report, EPA-SW-45D-72.

TABLE 56

STEEL AVAILABLE IN DISCARDED APPLIANCES, 1970 TO 1990

(In thousand tons)

Year	Clothes Dryers	Washing Machines	Ranges	Refrigerators	Water Heaters	Total, Five Major Appliances[a]	Total, All Major Appliances[b]
1972	75.4	324.9	278.4	436.8	207.1	1,323	1,720
1975	75.4	376.2	339.3	322.4	201.7	1,315	1,710
1980	121.8	350.6	287.1	426.4	245.3	1,430	1,860
1985	174.0	538.7	374.1	540.8	316.1	1,945	2,530
1990	214.6	530.1	391.5	540.8	381.5	2,060	2,680

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a/ Totals rounded.

b/ Includes room air conditioners, dehumidifiers, disposers, freezers, and dishwashers at approximately 30 percent of tonnage of five major appliances.

Source: Midwest Research Institute calculations based on Tables 50 to 55.

industrial establishments. On the basis of steel content of discarded appliances, the source of the type of waste is estimated in Table 57. As may be noted here, the point of discharge is not at all closely related to the point of use of the product as in cans or bottles. Instead, the influence of the practice of trade-in allowances and removal bv retailers gives a discard pattern unlike the use pattern. However, the effect may be beneficial to resource recovery since there are relatively large accumulations of appliances in one location. Thus, large loads could be hauled to a recovery plant or disposal site for processing. Of course, municipalities handle bulky waste collection from residences, but their loads are not as uniform in steel content (e.g., furniture, rugs, wood, etc.) as an appliance store, although the situation is similar since there is usually a common disposal site for bulky refuse.

TABLE 57

STEEL CONTENT OF DISCARDED APPLIANCES BY SOURCE, 1972 TO 1990
(In thousand tons)

Year	Total	Household	Commercial/ Institutional	Industrial
1972	1,720	570	1,115	35
1975	1,710	565	1,110	35
1980	1,860	615	1,210	35
1985	2,530	835	1,645	50
1990	2,680	885	1,740	55

Source: Midwest Research Institute estimates.

Steel recoverable from discarded appliances: Appliances are predominantly discarded by retail stores, second hand stores and charitable organizations. However, the concentration of tonnage must be sufficient to justify recovery activity. As in previous materials, we estimate that only SMSA's will produce enough flow of these wastes to consider commercial recovery activity. The total recoverable appliance steel was calculated on the basis of the methodology outlined in Chapter V, except that we used only the waste generation percentages in SMSA's for household population, not for commercial/institutional (Table 58). (The reason, of course, is that households get rid of the appliances, and commercial organizations only haul them away to repair or discard them.) In addition to this, the mechanical efficiency of recovery of shredded steel by magnetic separation is about 90 percent (slightly higher than for small pieces of steel which can escape recovery as fine particles).

TABLE 58

APPLIANCE STEEL WASTE GENERATION IN SMSA'S, 1972 TO 1990

(In thousand tons)

Year	Total Steel in Appliances	Total Steel in SMSA's	Recoverable Steel in SMSA's[a]
1972	1,720	1,180	1,060
1975	1,710	1,185	1,065
1980	1,860	1,310	1,180
1985	2,530	1,810	1,630
1990	2,680	1,950	1,755

[a] At 90 percent recovery efficiency.

Source: Midwest Research Institute estimates.

Appliance Steel Recycling Forecasts, 1972 to 1990

Very few major appliances are recovered for recycling of their steel content, primarily for economic reasons. After appliances have been shredded and the ferrous metal separated, the salable steel, for example, in a 200-pound refrigerator is worth about $2.00 at $24.00/ton scrap price. The collection cost and processing cost is high in comparison to the value of the steel for bulky waste--probably exceeding the value of the product.* However, we know of no comprehensive evaluation of bulky waste recovery in which the economics are developed in some detail.

There are three ways in which appliance steel will be recovered in the future. They are: (1) processing at large auto bulk shredding operations; (2) processing (shredding) at transfer stations or other special waste accumulation points; and (3) shredding in conjunction with centralized waste processing facility.

There is, today, some recovery of appliance scrap at auto shredders but this is probably not over a few thousand tons per year. The same is true of recovery at transfer stations. Because of the high cost of getting bulky waste to widely dispersed processing facilities, most of it ends up at land fills or junkyards and never is a part of the conventionally collected municipal waste stream.

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* See, for example, "Salvage Markets for Materials in Solid Waste," op.cit., p. 106.

Nonetheless, as the large central processing systems are installed and the auto shredders attempt to process more tonnage annually, a higher proportion of discarded appliances should enter the resource recovery cycle.

Our forecasts for appliance steel recovery are tied to the installation of central waste processing facilities from 1975 to 1990. The forecasts are developed in Table 59. The rate of processing of appliance steel for recovery is roughly one-fourth that of the rate of processing of mixed municipal waste. Thus, by 1990, we forecast that 5.1 percent of appliance steel will be recovered (from SMSA's) compared to about 25 percent of total mixed waste processed for other recovery. The processing rate could go much higher if the logistics problems and transportation to shredding facilities becomes more favorable than today.

This recovery will have little impact on total ferrous scrap recycling. The forecast recovery can be readily absorbed into steel scrap recycling mills because the recovered material would be comparable in quality to shredded auto bulks. The decision to make investments in shredding facilities will be tied partly to noneconomic factors such as shortage of landfill space, but the logistics and processing costs are key parameters that will have to be worked out over time.

TABLE 59

RECOVERY OF FERROUS METALS FROM APPLIANCES, 1972 TO 1990
(In thousand tons)

Year	Ferrous Metal Recovery From Appliances	Recovery as a Percent of Total Generated	Recovery as a Percent of SMSA's	Percent of Mixed Waste Processed in Central Facilities
1972	2 (est.)	0.1	0.2	neg.
1975	5	0.2	0.4	1.5
1980	15	0.8	1.1	4.1
1985	60	2.4	3.3	13.3
1990	100	3.7	5.1	24.3

Source: Midwest Research Institute estimates.

The total ferrous metal recovered from all municipal waste can be readily determined by adding the quantities recovered in Table 59 (for appliances) to the totals in Table 48 (for mixed waste). In 1972 total ferrous metal recovery was 70,000 tons; in 1975 it will be 0.28 million tons; in 1980, 0.59 million tons; in 1985, 1.72 million tons; in

1990, 3.15 million tons. The summary table for this chapter was included earlier as Table 36 which gives the recovery highlights for ferrous metals from all municipal waste sources.

CHAPTER VII

RECOVERY FORECASTS FOR ALUMINUM TO 1990

SUMMARY

The quantity of aluminum in mixed municipal waste will increase from 0.9 million tons in 1972 to 2.3 million tons in 1990. Aluminum waste is essentially equal to current demand for packaging plus aluminum in durable goods discarded annually.

The demand for aluminum packaging will increase at the rate of 6 percent per year between 1972 and 1990, from 0.7 million tons in 1972 to 2.0 million tons in 1990. Aluminum in appliances discarded added another 62,000 tons of waste in 1972 and will double to 124,000 tons in 1990. In 1990 the packaging aluminum will consist of 0.8 million tons foil and foil containers; and 1.2 million tons will be cans and can ends. Although the one-trip aluminum beverage container will continue to grow rapidly and partially displace glass and steel, aluminum beverage containers will begin to lose market share to plastic containers after 1980. The demand for aluminum cans for all uses will grow from 10.3 billion units in 1972 to 42.8 billion units in 1990 (about 90 percent will be beer and soft drink).

On a source basis, about 83 percent of aluminum packaging is discarded from households, 16 percent from commercial/institutional establishments, and 1 percent from industrial plants. By contrast, appliances and household items are sent to retail stores for discard and the source of aluminum in large appliances discarded was estimated at one-third household and two-thirds commercial/institutional.

The amount of aluminum packaging discarded in SMSA's will rise from 0.5 million tons in 1972 to 1.4 million tons in 1990. With the expected mechanical efficiency of recovery systems about 0.9 million tons would be recoverable in 1990.

Aluminum recovered from municipal waste can be recycled by the primary aluminum producers, but the alloy content of aluminum consumer packaging in waste makes it desirable for recycling via secondary smelters. Can collection programs will carry the brunt of the recovery methods until about 1980. This is because the technology and economics of mechanical recovery systems is still unproven in use and it will be several years before commercial recovery systems are in place and proven. Once mechanical systems are avilable, can collection programs will give way to aluminum processing at centralized units, landfills, or transfer stations. Thus, two recovery mechanisms will be in use--mechanical separation from mixed waste and voluntary can collection, the former becoming important about 1980.

The MRI forecasts of aluminum recovery are summarized for the 1972 to 1990 period in Table 62.

TABLE 62

SUMMARY OF ALUMINUM RECOVERY FROM MUNICIPAL WASTE, 1972 TO 1990
(In thousand tons)

Type of Recovery	1972	1975	1980	1985	1990
Volunteer can collection	27	50	80	80	80
Mechanical separation	0	1	24	198	425
Appliance processing	0	0	1	2	5
Total	27	51	105	280	510
Recovery as a percent of:					
Aluminum waste generated	3.0	4.2	7.0	14.7	22.2
Aluminum in SMSA's	5.2	7.1	10.7	22.7	33.6

The recovery of aluminum will rise from 27,000 tons in 1972 to 510,000 tons in 1990; or from 3.0 to 22.2 percent of the total waste aluminum generation. After 1980, mechanical separation will grow rapidly, especially at central resource recovery facilities. Most of the aluminum recovered (over 90 percent) will go to primary aluminum producers; a small amount could go into secondary smelting. MRI's recovery forecasts are comparatively optimistic for aluminum; the metals contribution to municipal waste is very low, but its value is very high ($200/ton or more).

INTRODUCTION

The only nonferrous metal that occurs in significant quantities in municipal waste is aluminum, principally because this metal has become an important container and packaging material, used in cans, foil, trays, etc., for a variety of applications. Other waste aluminum products add a small amount to municipal waste.

Packaging activity in the United States has been growing at a rapid rate over the past decade and aluminum used in packaging is no exception. Packaging accounted for 14 percent of aluminum production in 1972 and it is expected that this figure will increase to 20 percent of aluminum production by 1990. The principal growth sector will be aluminum cans for beer and soft drinks.

ALUMINUM PACKAGING DEMAND BY MARKET, 1962 TO 1990

Introduction

The most common uses for aluminum packaging are foil for lamination, wrapping and semirigid trays, and sheet for cans and can ends for beverages and food. Aluminum packaging for foil and semirigid container packages is well established and the trends continue to show that there will be an increased use of aluminum in foil products in the future.

In recent years there has been a trend toward the increased use of aluminum foil type packaging for reasons other than containment or protection. Special service packaging has resulted in the need for a package that will retain heat or cold for a period of time and still be strong enough to protect what it contains; aluminum fills this need.

The growth in the use of aluminum as a packaging material has been quite high over the past 12 years. The average annual growth rate between 1960 and 1972 was more than 16 percent, although the growth rate is not expected to be this high in the future.

It is expected that environmental concerns and the "energy crisis" will tend to slow the growth in aluminum packaging some degree, but aluminum packaging is still expected to grow at approximately 6 percent per year. Aluminum packaging will continue to be competitive with steel, glass, plastics and paper. In fact, it will likely displace steel and glass as it has in recent years, especially in beverage containers; only plastic beverage containers will capture a share of beverage "one-way" packaging in preference to aluminum.

Aluminum Cans*

Aluminum cans came into common use in 1963 and have had a rapid and steady growth in demand. The market penetration of aluminum reflects several features of cans: corrosion resistence; attractively sloped and printed; light weight; versatility in size, slope and wall thickness; no metallic taste is transferred to "sensitive" products.

The aluminum industry, developed the aluminum "easy open" and pull-tab opener for beer cans in about 1960. It was readily accepted and by 1965, 70 percent of the beer cans had the aluminum pull-tab end. It is estimated that 95 percent of the present beer cans have aluminum tops.

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* The details of competitive aspects of demand for aluminum cans are covered in Chapter VI and Appendix A and are not repeated here.

Unit Demand: The success of aluminum beer packaging also spurred the development of the two-piece "drawn and ironed" aluminum can. This can is manufactured from thin aluminum, producing a can weighing about half that of a steel can. It requires less metal since it is drawn from a round blank of metal and stretched (ironed) to the desired length. This two-piece can does not have a side seam and can be lithographed on the entire exterior of its body, providing a more attractive package for consumer eye appeal. Growth was rapid during the latter years of the 1960 decade and by 1972, aluminum cans had captured 32 percent of the beer can market with 6.9 billion two-piece drawn and iron aluminum cans.

The total demand for aluminum cans was 10.3 billion units in 1972 and will rise to 42.8 billion units in 1990 (Table 63); most of these will be beverage containers.

TABLE 63

ALUMINUM CAN DEMAND, 1972 TO 1990
(In millions of cans and thousand tons)

Category	1972	1975	1980	1985	1990
Units:					
Beer	6,900	12,500	19,500	25,000	31,000
Soft Drinks	1,600	3,000	5,000	5,500	6,000
Other types	1,800	2,400	3,600	4,700	5,800
Total Cans	10,300	17,900	28,100	35,200	42,800
Tonnage:					
Input total					
Cans	350	613	938	1,175	1,400
Ends	225	225	225	225	225
Total	575	838	1,163	1,400	1,625
Scrap	172	251	350	420	488
Net Usage	403	587	813	980	1,137

Source: Midwest Research Institute.

Packaged beer is and will continue to be the largest market for aluminum. Demand for an estimated 6.9 billion aluminum cans in 1972 will increase to 19.5 billion in 1980 when they will have captured 58 percent of the beer can market and growing to 31.0 billion units in 1990.

At present, only 10 percent of the soft drink cans are aluminum, with the balance made from steel. The demand for aluminum cans will increase from 1.6 billion units in 1972 to 5.0 billion by 1980, equivalent to 20 percent of the soft drink can market. By 1990, a modest growth rate will have brought aluminum cans in soft drinks to a level of 6.0 billion units.

After 1980, aluminum cans are expected to give up market share to plastic beverage containers, although the growth in number of cans and tonnage used will increase steadily to 1990.

Aluminum cans have penetrated some end uses besides beverages (5 ounce single service easy-open cans for puddings, meat, and fruit). Although rapid growth was predicted for those markets only about 1.5 billion were used in 1972. Growth of aluminum will be steady reaching 3.0 billion containers by 1980, and 5.0 billion by 1990.

In addition, a small number of aluminum containers are used to package aerosols. These are generally limited to small containers because of their higher costs. Because they are two-piece cans, they have greater design flexibility than steel three-piece cans. Extimated at 10 percent of the aerosol can market in 1972, aluminum is expected to increase its share to 15 percent by 1980.

Tonnage Demand: The Aluminum Association reports shipments of aluminum sheet for containers and packaging. Industry sources believe their statistics to be a reliable estimate of aluminum consumed in can manufacturing. However, these statistics do not document the amount shipped in finished cans, only the quantity of input metal to cans. Aluminum can stock results in 28 to 30 percent scrap for a two-piece drawn and ironed can.* The scrap is sent back to remelt furnaces and never really leaves the production cycle.

An estimated 575,000 tons of aluminum sheet input was used in 1972 to manufacture 403.000 tons of cans (Table 63). Approximately 85 percent of this metal was used for all aluminum beverage cans and for steel beverage can ends. The balance went into food products such as snack, seafood, etc. and in oil can ends. Growth in the beverage market will more than double metal consumption to 1.16 million tons input by 1980, which will result in 813,000 tons of finished cans. Ends for steel cans are projected to remain at the current level of 225,000 tons because of the development of an "easy-open" steel end combined with the slower growth rate for steel cans. Actual consumption of aluminum in the finished can is estimated at 403,000 tons in 1972 at a scrap rate of 30 percent. By 1990, there will be 1.14 million tons of aluminum in cans.

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* Source: Reynolds Metals Company estimate.

It is expected that efforts to reduce the use of one-way beverage containers will be successful in some of the more environmentally conscious states, e.g., Oregon, Vermont, and a few others, but it is not expected that total demand will be significantly affected by anything short of national legislation restricting the use of aluminum packaging materials. We did not consider federal legislation in our forecast.

Foil Packaging

The net output of semirigid and nonrigid aluminum foil packaging will increase from 291,000 tons in 1972 to 830,000 tons in 1990 (Table 64). At the same time aluminum cans and ends will increase from 403,000 tons output in 1972 to 1.14 million tons output in 1990.

Waste Generation From Aluminum Packaging

Most aluminum packaging is used by the consumer and disposed of almost as purchased. The main reason for this is that aluminum packaging is principally to contain a food product that will be consumed within days or months of purchase, even if it is a frozen variety. It is fairly certain that the package will be disposed of within a year after purchase. In some cases (as decorative items), the consumer will withhold the used container from the waste stream for one reason or another. However, aluminum cans and foil type containers are usually disposed of immediately after use, and retention practices of consumers are not significant enough to warrant special consideration.

Aluminum Packaging Waste Generation by Source

Most aluminum packaging material contains products used in the home, and a majority of aluminum packaging waste will come out of the household. Aluminum cans and foil are used for similar application--in home or retail food packaging that goes to the home for use. The basis for allocating aluminum packaging waste by source was the same as that used for steel (see Chapter VI, section on waste generation by source). The distribution of waste is 83 percent household; 16 percent commercial/ institutional and 1 percent industrial (Table 65).

TABLE 64

ALUMINUM METAL DEMAND IN PACKAGING, 1960 TO 1990

(In Thousand Tons)

Year	Aluminum Foil Use In: Semi Rigid Foil Containers	Aluminum Foil Use In: Nonrigid Aluminum Foil	Aluminum Foil Use In: Total Foil	Input Metal for Aluminum Cans and Ends	Aluminum in Finished Cans and Ends[a]	Total Aluminum Demand in Finished Products[b]
1960	27	87	114	25	18	132
1965	40	125	165	94	66	231
1970	63	202	265	352	246	511
1972	71	220	291	575	403	694
1975	95	290	385	838	587	972
1980	115	400	515	1,163	813	1,328
1985	150	510	660	1,400	980	1,640
1990	220	610	830	1,625	1,137	1,967

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[a] Adjusted at a scrap rate of 30 percent.

[b] Note: These data do not correspond to Aluminum Statistical Review published annually by the Aluminum Association. This source reports shipments of metal as input for containers and packaging. The values given above have been adjusted for fabrication scrap (called "run around scrap" in the industry) and represents shipments of finished products.

Source: Marketing Guide to the Packaging Industries, 1972 Charles H. Kline, Inc.; Midwest Research Institute.

TABLE 65

ALUMINUM PACKAGING WASTE BY SOURCE, 1972-1990
(In thousand tons)

Year	Total Aluminum Contained in Packaging	Distribution by Source of Discard		
		Household	Commercial-Institutional	Industrial
1972	694	576	111	7
1975	972	807	155	10
1980	1,328	1,102	213	13
1985	1,694	1,362	262	16
1990	1,967	1,632	315	20

Source: Midwest Research Institute estimates.

Litter: As previously estimated* we have assumed a 2 percent litter factor for the beverage container portion of aluminum packaging.* This amounts to 8,000 tons in 1972; 11,000 in 1975; 15,000 in 1980; 19,600 in 1985; and 22,000 in 1990.

Aluminum Packaging Waste Recoverable

The values for recoverable aluminum packaging waste were calculated by taking the amount of aluminum that is generated in the SMSA's (approximately 68 percent of total waste based on population in 1972) and applying the SMSA population ratio and commercial/institutional ratios of Table 31. If all of this material were processed for recovery, the mechanical recovery efficiency would further reduce recoverable waste (Table 69). We estimate that recovery systems for aluminum will be about 65 percent efficient. Thus, of total aluminum packaging waste generated, about 44 to 48 percent is ultimately recoverable for recycling.

ALUMINUM IN CONSUMER DURABLE PRODUCTS

This market sector, consisting of refrigerators, air conditioners, ranges, dishwashers, washers and the like, contribute a significant amount of aluminum as well as other metals to the waste stream. However, aluminum recovery from these products is virtually nonexistent because of the processing required to recover the aluminum from discarded appliances.

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* See Chapter V.

TABLE 66

RECOVERABLE ALUMINUM PACKAGING WASTE, 1972-1990
(Thousand tons)

Year	Packaging Waste Entering Waste Stream[a]	Packaging Waste Generated in SMSA's	Amount Recoverable By Mechanical Systems
1972	686	473	305
1975	961	668	435
1980	1,312	920	600
1985	1,621	1,150	750
1990	1,945	1,430	930

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a/ Less litter not recovered.
Source: Midwest Research Institute estimates.

At the present time, there are an estimated 300 million major appliances in use in the United States. They are being discarded at a rate of approximately 15 million units a year and this figure is expected to rise to 22 million units by 1980.*

The aluminum potentially available can be calculated by multiplying the aluminum in each appliance by the number of appliances retired each year. The amount of aluminum in various appliances varies from 2 to 15 pounds per unit (Table 67). The number of appliances that will be discarded annually was partially developed in Chapter VI and summarized here with room air conditioners and dishwashers added (Table 68). The total discards multiplied by the average amount of aluminum in each type of appliance gives a value for the aluminum that would be available from discarded appliances (Table 69).

These estimates give a general indication of how much aluminum might be available for recovery should technology overcome processing handicaps now preventing efficient separation of metals from various appliances.

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* See Chapter VI.

TABLE 67

ALUMINUM USAGE IN SELECTED APPLIANCES, 1970

(In pounds per unit)

Appliance	Amount of Aluminum Contained in Appliance (pounds)
Room Air Conditioners	10
Ranges	2
Refrigerators	9
Dishwashers	2
Washers	15
Dryers	4

Source: National Industrial Pollution Control Council, The Disposal of Major appliances, 1971, pp. 18-19.

TABLE 68

ANNUAL APPLIANCE DISCARDS, 1972 TO 1990

(In millions of units)

Appliance	1972	1975	1980	1985	1990
Room Air Conditioners	1.6	3.0	5.9	7.0	8.1
Ranges	3.2	3.9	3.3	4.3	4.5
Refrigerators	4.2	3.1	4.1	5.2	5.2
Dishwashers	0.7	1.3	2.1	3.0	3.2
Washers	3.8	4.4	4.1	6.3	6.2
Dryers	1.3	1.3	2.1	3.0	3.7
Total Discards	14.8	17.0	21.6	28.8	30.9

Source: National Industrial Polltuion Control Council, The Disposal of Major Appliances, 1971, pp. 18-19; Midwest Research Institute (Chapter VI).

TABLE 69

POTENTIAL ALUMINUM AVAILABLE IN APPLIANCES, 1972 TO 1990

(In thousand tons)

Appliance	1972	1975	1980	1985	1990
Room Air conditioners	8	15	30	35	40
Ranges	3	4	3	4	5
Refrigerators	19	14	18	23	23
Dishwashers	1	1	2	3	3
Washers	28	33	31	47	46
Dryers	3	3	4	6	7
Total	62	70	88	118	124

Source: Midwest Research Institute estimates.

Appliance Aluminum Waste by Source

Estimates were made to give waste generation by source for appliances. As estimated in Chapter VI, the predominant majority are discarded from commercial establishments because that is where appliances go after retirement (as trade-ins). We allocated 33 percent to household and 67 percent to commercial/institutional (Table 70). Our estimate of the tonnage available in SMSA's is also given in Table 70.

TABLE 70

ALUMINUM WASTE IN APPLIANCES BY SOURCE, 1972 TO 1990

(In thousand tons)

Year	Total Aluminum Generated	Household	Commercial-Institutional	Industrial[a]	Available in SMSA's
1972	62	19	43	neg	42
1975	70	23	47	neg	48
1980	88	29	59	neg	61
1985	118	39	79	neg	83
1990	124	41	83	neg	90

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a/ Less than 1 percent.

Source: Midwest Research Institute estimates.

Recoverability of Aluminum in Appliances

At present, the only techniques for recovering metals from discarded appliances are isolated incidences of secondary materials dealers and auto shredders that "breakdown" appliances by labor intensive techniques. The processing required to separate the metals is labor intensive and expensive. Most of this potential aluminum is lost. Should the technology be developed to efficiently separate metals in appliances for processing, recovery of aluminum and other metals could take place. Technology of this type is likely to have to be tied to shredding and magnetic removal of ferrous fractions followed by an aluminum magnet; heavy media separation of other mineral dressing techniques.

Aluminum Recoverable From Municipal Waste

Estimates of total waste generation from aluminum packaging and in appliances can now be given. MRI's forecast of total waste generation and waste available in SMSA's is given in Table 71.

TABLE 71

SUMMARY OF ALUMINUM WASTE GENERATION, 1972 TO 1990
(In Thousand Tons)

Source of Waste	1972	1975	1980	1985	1990
Packaging	686	961	1,312	1,621	1,945
Appliances	62	70	88	118	124
Total	748	1,031	1,400	1,739	2,069
Packaging - SMSA's	473	668	920	1,150	1,430
Appliances - SMSA's	42	48	61	83	90
Total SMSA's	515	716	981	1,233	1,520

Source: Midwest Research Institute.

RECOVERY FORECASTS FOR ALUMINUM, 1972 TO 1990*

Recovery From Mixed Waste at Centralized Processing Systems

The increasing consumption of aluminum, the lack of domestic reserves, and the energy expenditure required for virgin aluminum production lead to the conclusion that aluminum recovery from municipal waste for recycling will be pursued actively in the future.** Aluminum is the most valuable single constituent of significant tonnage in municipal solid waste, and its scrap value of $200 per ton (or more) makes it an attractive material to separate from municipal waste. However, there are not yet any commercial separation techniques for separating aluminum from mixed wastes.

Based upon our estimates of municipal solid waste generation, aluminum packaging constituted about 0.5 percent of the waste in 1972 (assuming no removal of aluminum in collection centers). It will rise to 1.0 percent by 1990. At these concentrations (20 pounds per ton of waste), a ton of waste contains $2.00 worth of aluminum at $200 per ton. As centralized waste processing units are installed, the recovery of aluminum will be an "add on" process. Whenever technology becomes available, it will be attractive to recover the aluminum because of its high value.

Recovery techniques are under development that would separate highly concentrated nonferrous metals fractions. Dense media separation and an electromagnetic separation process appear to hold the most promise at present. We believe that efficient recovery technology should be available by 1980 and then aluminum will be recovered from centralized waste processing facilities along with other inorganics such as steel. On this basis we have estimated aluminum recovery from central waste processing facilities to be 1,000 tons in 1975 and rising to 365,000 tons in 1990. It will be 1985 before these systems are fully equipped to recover aluminum.

Recovery of Aluminum Via Other Methods

Presently, aluminum can recovery is virtually the exclusive forte of the primary metals producers and beverage makers, e.g., Alcoa, Reynolds, Kaiser, Coors, etc., who operate consumer collection centers. The present recovery (1972) of beverage cans is about 15 percent or 27,000 tons of the total metal used in beverage cans. The recovery of aluminum cans at collection centers has increased rapidly under the efforts of the aluminum and beverage industries.

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* Trends in scrap use for the entire aluminum industry are given in Appendix B.

** Alternately, the use of aluminum packaging might decline if recycling does not take place.

However, recovery from can collection will not grow as rapidly in the future. MRI estimates that collection centers would reach a limit of 140 to 150,000 tons of cans recovered per year by 1990, if past trends continued. In actuality, our estimates are that can collection programs will peak at 80,000 tons per year as mechanical separation at central processing facilities and transfer stations come on-stream after 1980. To accomplish even this goal will require that separately collected cans increase by three fold over 1972.

As mechanical recovery becomes available, it will be installed at centralized waste processing sites. By 1980, only 10,000 tons will be recovered from central waste processing systems, but by 1990, 365,000 tons will be recovered at central waste processing systems (Table 72).

TABLE 72

RECOVERY OF ALUMINUM FROM MIXED MUNICIPAL WASTE AT CENTRALIZED PROCESSING SYSTEMS, 1972 TO 1990

(In thousand tons)

Category	1972	1975	1980	1985	1990
Total Waste Generated	130,000	140,000	160,000	180,000	200,000
Aluminum in Waste[a]	900	1,200	1,500	1,900	2,300
Percent Aluminum	0.7	0.9	0.9	1.0	1.2
Total Waste Processed in Centralized Recovery Systems	neg.	2,100	6,600	24,000	48,600
Aluminum Content	neg.	18	62	250	560
Aluminum Recovery at .65 Recovery efficiency (1985-1990)	neg.	1	12	165	365

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[a] Prior to any type of recovery at the source or other points. Includes all aluminum in mixed waste, including appliances, packaging and non-packaging uses of aluminum in Table 11. (Note that the total aluminum waste is greater than that of packaging and appliances alone.)

Recovery of aluminum from mixed waste is not even technically demonstrated on a commercial scale yet, and probably will not be until 1975. When recovery does become feasible around 1980, some separation will take place at transfer stations, landfills and incinerators using mechanical systems. Based on our recovery estimates for ferrous metals, by 1980 "front end" type systems operating at transfer stations and landfills will recover an estimated 12,000 tons of aluminum from mixed waste. This is the amount of aluminum in about 2.2 million tons of mixed waste. By 1985, a total of 33,000 tons will be recovered and by 1990 there will be 60,000 tons recovered. This means that about 12 million tons of waste will be processed for aluminum recovery (Table 73), outside of voluntary and large central processing systems.

We expect the recovery systems to be justified on their own merits with or without recovery of paper, steel, glass or other recyclable materials. The technology would be much the same as used in centralized waste processing units except that there would be no recovery of energy from the organic fraction of waste--i.e., aluminum magnets or mineral dressing techniques applied to previously shredded and concentrated inorganic fractions of waste.

There will be some recovery from appliances in conjunction with shredding and special appliance processing. However, the aluminum content of appliances is not attractive to recover because of the logistics of appliance collection and processing and the relative difficulty of removal of the metal by mechanical means. By 1980, 1,000 tons might be recovered from appliances; by 1985, 2,000 tons; by 1990, 5,000 tons recovered.

The preceding figures, it is obvious, do not indicate a rapidly stepped up program of aluminum recovery in the near future. Actual aluminum recovery from the municipal waste stream is expected to be under 5 percent in 1975, but will be 14.7 percent of total recovery by 1985, and 22.2 percent by 1990. This translates to 51,000 tons in 1975 and 510,000 tons in 1990 (Table 73). It should be noted that our recovery forecasts for aluminum should be considered "optimistic" in comparison to some of the other materials.

These figures are, of course, somewhat speculative, since the art of recovering aluminum from municipal waste is in its infancy and the appearance of new technology, which could significantly raise the amount of aluminum being recycled, is unproven. Nonetheless, the combined pressures of the "energy crisis," the inherent value of the metal for recycling, and favorable resource recovery economics will all encourgae additional recovery for recycling.

TABLE 73

SUMMARY OF ALUMINUM RECOVERY FROM MUNICIPAL WASTE, 1972 TO 1990

(In Thousand Tons and Percent)

Type of Recovery	1972	1975	1980	1985	1990
Volunteer can collection	27	50	80	80	80
Mixed waste processing	0	0	12	33	60
Centralized recovery systems	0	1	12	165	365
Appliance processing	0	0	1	2	5
Total Recovery	27	51	105	280	510
Total recovery as a percent of:					
Aluminum waste generated	3.0	4.2	7.0	14.7	22.2
Aluminum waste in SMSA's	5.2	7.1	10.7	22.7	33.6

Source: Midwest Research Institute.

CHAPTER VIII

RECOVERY FORECASTS FOR PLASTICS TO 1990

SUMMARY

The quantity of plastics in mixed municipal waste will increase from 4.5 million tons in 1972 to 13.2 million tons in 1990. Plastic waste is essentially equal to final product demand and consists principally of packaging plastics. The demand for plastics in all types of packaging applications will increase at a rate of 6.4 percent per year between 1972 and 1990. Plastic packaging use will increase from 3.0 million tons in 1972 to 8.9 million tons in 1990. Almost all uses, including film and blow molded containers, will become much more important at the expense of conventional materials--glass, metals and paper. The plastic beverage container will become a large factor in plastic demand after 1980.

On a source basis, about 84 percent of plastic waste is generated in households; 10 percent in commercial/institutional and 6 percent in industrial locations. There will be a trend to a lower percentage in household waste by 1990, about 78 percent of the total. By 1990, this will mean 6.9 million tons of plastics wastes will be coming out of household and about 11 million tons each will be generated by commercial and institutional establishments.

The plastics content of mixed waste will increase from 3.5 percent of total waste in 1972 to 6.6 percent in 1990.

Looking at the recovery base (SMSA's) there will be 10 million tons of plastic potentially available for resource recovery in 1990. Recycling of post-consumer plastics will not become a significant recovery option in the period to 1990. However, plastics in mixed waste will provide a very good source of Btu potential for energy recovery options.

We have forecast the installation of a significant number of centralized waste processing facilities for energy (fuel) recovery (Chapter III). The forecasts for plastic recovery and energy use are summarized in Table 74.

The recovery of plastics from municipal waste in the form of fuel or energy will rise from essentially zero in 1972 to 3.2 million tons in 1990 (24.3 percent of the total plastics waste generation). This quantity will yield 96.3×10^9 Btu of energy in 1990 from resource recovery systems. The increasing use of plastics will also serve to "upgrade" the Btu content

TABLE 74

SUMMARY OF PLASTICS RECOVERY, 1972 TO 1990

(In Thousand Tons)

Year	Total Plastics Waste Available	Total Plastics in SMSA's	Amount Processed for Recovery	Recovery in Energy 10^6 Btu	Recovery as a percent	
					Total	SMSA's
1972	4,500	3,100	0	0	0	0
1975	5,700	3,970	85	2,550	1.5	2.1
1980	8,400	5,925	350	10,500	4.2	5.9
1985	11,000	7,900	1,470	44,100	13.4	18.6
1990	13,200	9,615	3,210	96,300	24.3	33.3

Source: Midwest Research Institute

of mixed waste because plastics (derived from petroleum feedstocks) have a much higher Btu content than paper, food or yard wastes at an average of 15,000 Btu per pound of plastic.

INTRODUCTION

Plastic resins are widely used in the manufacture of a variety of containers, caps and closures, film, coatings, and "disposable" items. Plastics have achieved most of their growth since World War II. The continual reduction of costs associated with increased volume; improved technology for fabricating and forming plastics; and low cost petrochemical raw materials* made them competitive with the traditional packaging materials such as paper, metal cans and glass containers.

Packaging uses accounted for 23.7 percent of the 11.8 million tons of plastics produced in 1972 or 2.8 million tons. Packaging accounts for half of all polyethylene produced, 21.8 percent of the polystyrene and lesser amounts of polyvinyl chloride (PVC) and polypropylene (Table 75). Non-packaging plastics go into a multitude of products--from records, raincoats, garden hose to appliances, autoparts, construction products etc.

TABLE 75

PLASTIC RESINS INPUT QUANTITY FOR ALL USES AND PACKAGING, 1972[a]
(In thousand tons)

Resin	All Uses	Packaging	Percent of Packaging
Polyethylene, LD	2,610	1,398	53.5
Polyethylene, HD	1,195	558	46.6
Polystyrene	1,840	401	21.8
Polypropylene	865	119	13.8
Polyvinyl/chloride (PVC)	2,120	160	7.5
All Others	3,170	160	5.0
Total	11,800	2,796	23.7

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a/ This is resin use which is nearly the same as finished goods output.
Source: U.S. Tariff Commission and Midwest Research Institute estimates.

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* At least prior to 1973 when petroleum prices were low in relation to other natural resources.

PLASTIC PACKAGING RESIN DEMAND, 1965 TO 1990

General Trends in Packaging Plastics Demand to 1990

Plastic packaging materials plus cellophane* demand grew at a rate of 14.5 percent per year between 1965 and 1972. Demand has increased during this period from 1.14 million tons per year to 2.96 million tons per year (Table 76). Low density polyethylene (which is used extensively as a film) is the largest volume resin with 1.4 million tons consumed in 1972.

TABLE 76

PACKAGING PLASTICS DEMAND BY TYPE OF RESIN, 1972-1990
(In thousand tons)

Resin	1965	1972	1975	1980	1985	1990
Polyethylene LD	465	1,398	1,713	2,275	3,100	3,930
Polyethylene HD	150	558	747	1,150	1,500	1,825
Polystyrene	212	401	527	864	1,120	1,380
Polyvinyl Chloride	35	160	206	288	360	450
Polypropylene	30	119	178	358	520	690
Cellophane	200	163	145	125	100	75
All Other	50	160	179	240	400	550
Total	1,142	2,959	3,695	5,300	7,100	8,900

Growth Rate Percent Per Year	PE-LD	PE-HD	PS	PVC	PP	Total
1965-1972	17.0	20.7	9.5	24.3	21.8	14.6
1972-1980	6.3	9.4	10.0	7.6	14.8	7.6
1980-1990	5.8	4.7	4.8	4.6	6.8	5.7

Source: Midwest Research Institute Forecasts; 1965 and 1972 based on "Modern Packaging" statistical reports for January 1966 and 1973.

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* Cellophane is not a plastic,but it is included with packaging plastics because it is a common packaging material commonly associated with plastic films.

The demand for plastics in packaging will not increase as rapidly in the future as it has in the past, because: (1) many markets are maturing which were developed in the past decade, and (2) a dramatic trend to higher energy costs. Although plastics should retain their current cost competitiveness with paper, aluminum, glass and steel packaging materials, marginally profitable markets will be less actively pursued in the future by plastic makers.

Resin demand will increase at 7.6 percent per year from 1972 to a level of 5.3 million tons in 1980. Beyond 1980 demand will increase at 5.7 percent per year reaching a level of 8.9 million tons in 1990 (Table 76).

Resin Use by Type of Resin

Low density polyethylene: Low density polyethylene is the largest volume packaging resin representing 47.3 percent of all packaging in 1972. It is used principally as a film for wraps and bags and as a coating for paperboard. Trash bags, which are a recent development, represent the largest single use for low density film with an estimated consumption of 250,000 tons of resin in 1972. Food wrap and bags, garment bags, consumer goods wraps and pallet wrap represent other large film uses. These end uses represented a demand for 1.07 million tons of film in 1972.

Approximately 225,000 tons of low density polyethylene were used to coat paperboard, paper and foil in 1972. Approximately half of this was used to coat paperboard milk cartons. Future demand for coatings will be reduced as the plastic milk container displaces in part the coated milk carton.

The consumption of low density polyethylene will grow to a level of 2.3 million tons in 1980 from 1.4 million tons in 1972. Much of the growth will come from shrink films for pallet wrap, beverage packs, and from trash bags.

High density polyethylene: High density polyethylene is used primarily for blow molding rigid containers used to package food and consumer products. It is also used for injection molding beverage cases, pallets, jars and lids, and thermoforming food containers and medical packages.

High density polyethylene for packaging has grown at a rate of 20.7 percent per year since 1965 to a level of 558,000 tons in 1972. Future growth is projected at 9.4 percent per year to 1980 when consumption will be 1.15 million tons. Blow molded containers for milk, medicinal and health, and other containers, plus molded beverage cartons and pallets will continue.

By 1990, 1.83 million tons of HD polyethylene resins will be consumed in packaging uses.

Polystyrene: Polystyrene has grown at a slower rate in packaging than other resins. Demand since 1965 has been increasing at 9.5 percent per year, reaching a volume of 401,000 tons in 1972. Polystyrene is nearly all injection molded--into a wide variety of boxes, trays, cups and lids, or thermoformed into meat trays, thin-walled containers and single service dinnerware. Expandable foams are molded into cups, boxes, trays and packaging inserts or stamped into meat trays, egg cartons and other food packages.

Polystyrene demand is projected to increase at 10 percent per year to 1980, when 864,000 tons of resin will be consumed. Growth in existing uses and the development of institutional markets for single service dinnerware will account for most of the increase. By 1990, 1.38 million tons of polystyrene will be consumed for packaging and "disposables."

Polyvinyl chloride (PVC): Packaging represents only 7.5 percent of the total demand for PVC. PVC film is used as a wrap for fresh meat and produce and as a shrink film for carton wraps. It is also formed into clear rigid containers for food and consumer products where oil and oxygen resistance is desired. PVC sheet is used for blister packaging of consumer items to provide visibility for consumer products.

Consumption of PVC for packaging reached 160,000 tons in 1972 and is projected to increase at 7.6 percent per year to 1980 when demand will be 288,000 tons. Growth will occur in most packaging end uses except rigid containers. Growth will be limited there because of high cost and potential health questions raised by FDA officials for food and beverage containers.

Polypropylene: Approximately 119,000 tons of polypropylene were consumed for packaging applications in 1972. Its largest use is as a packaging film that competes with polyethylene and cellophane for food, textiles and a host of other markets. Injection molded hinged lid containers are made from polypropylene as are plastic straws.

Demand for polypropylene resin will increase at 14.8 percent per year to a level of 358,000 tons by 1980, with most of the growth coming from film markets. The relative cost difference between polyethylene and polypropylene is expected to narrow in the future so that this growth rate can be obtained.

Cellophane: Cellophane,which is a cellulosic material used as film,is used to package baked goods, meat, tobacco, cookies and a wide variety of foods. Demand has been declining as it is gradually replaced by plastic films. Consumption of 160,000 tons in 1972 is projected to decline to 75,000 tons by 1990. If other plastics (PVC) cannot be used in food applications, the cellophane usage may not decline as much. However, other resins may be developed to replace any markets lost in the short run so that cellophane should decline in consumption by 1990.

Other resins: A variety of other resins account for the remaining 160,000 tons of packaging materials. Thermosetting resins for caps and closures, vinyl acetate for coatings, cellulosics for blister packaging, specialty film resins, and the newly developed barrier resins for rigid containers are included. Demand will begin to increase rapidly during the latter part of the decade as the barrier resins penetrate the soft drink market. Consumption of the "miscellaneous" resins will increas to 240,000 tons in 1980 and 550,000 tons by 1990.

Resin Demand by End Use*

Film resins used to manufacture bags and wraps represent 48 percent of all resins consumed in packaging markets and will retain this proportion through 1980. Blow molded containers and miscellaneous thermoformed and injection molded products are the other major end uses. These uses and trends in demand are shown in Table 77 and discussed below.

TABLE 77

PLASTIC PACKAGING RESIN DEMAND BY END USE, 1972-1990
(In thousand tons)

End Use Category	1972	1975	1980	1985	1990	1972-1990 Growth Rate
Film	1,416	1,800	2,555	3,380	4,200	6.1
Miscellaneous Packaging	641	825	1,350	1,960	2,565	8.0
Blow Molded Containers	458	610	920	1,270	1,620	7.1
Coatings	349	350	350	360	375	0.4
Closures and Caps	95	110	125	130	140	2.0
Total	2,959	3,695	5,300	7,100	8,900	6.4

Source: "Modern Packaging," January 1973; Midwest Research Institute Forecasts.

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* A more detailed analysis of plastic resin demand by end use and resin source is given in Appendix D.

Film: About 792,000 tons of plastic resin were used in film and flexible packaging in 1972. By 1990, the demand will grow to 4.2 million tons, or 530 percent of 1972 use. LD polyethylene accounts for about three-fourths of this demand. The growth markets have been: food product packaging, e.g., baked goods and fresh produce; shrink wrap for pallets; trash bags and miscellaneous packaging. While resin use for film will increase several fold by 1990, cellophane film will decline.

Miscellaneous packaging: In 1972, a total of 641,000 tons of resin was used to produce miscellaneous packaging products. These are generally products formed by thermoforming and injection molding--caps, tubes, boxes, trays, cartons, jars, tubs, pads, and blister packs. By 1990, we have forecast a total demand in this category of 2.5 million tons or four times the 1972 demand. In this group, polystyrene accounts for over one-half of the resin demand; polythylene accounts for another one-third of the resin used. Impressive growth rates are forecast--8 percent per year between 1972 and 1990, the highest of the five end use categories in plastic packaging.

Blow molded containers: About 458,000 tons of plastic resin was used in producing 6.73 billion containers in 1972. By 1990, output is expected to be 24.5 billion containers or 360 percent of 1972 output. In terms of resin of all types, there will be 1.6 million tons demand for blow molded containers in 1990. Beverages, toiletries and cosmetics, and medical and health products will account for over 5 billion containers each or 15.7 billion units. Most of the tonnage will be HD polyethylene (1.2 million tons), despite the fact that barrier resins will be used to make beverage containers.

Coatings: Plastic coatings are used on paper products such as multiwalled shipping sacks, paperboard milk cartons (the largest single use), on film, and on foil. In total, there were 350,000 tons used in 1972. Growth is not expected to be significant. The primary reason is that this is a mature market, and also the expectation that polyethylene coated milk cartons will partially be displaced by plastic milk containers. By 1990, we forecast demand of 375,000 tons of resins for coatings.

Closures and caps: Plastics accounts for about 14 percent (13 billion units) of the total market for closures and caps produced annually. Most plastic caps and closures are used on glass and plastic containers. Both thermoplastic and thermosetting plastics are used for caps and closures. Total demand will increase modestly in the future and will be at 140,000 tons in 1990, which translates to a 1972 to 1990 growth rate of 2 percent per year.

As shown in Table 77, the demand for all plastics in packaging will increase from 3.0 million tons in 1972 to 8.9 million tons in 1990 or 300 percent of 1972 demand. This is a growth rate of 6.4 percent over the 18-year period. Thus, while the "conventional" steel and glass materials used for packaging will increase slowly over this period, the petroleum derived plastics will continue to make inroads into packaging applications.* This increase in plastics use in packaging will be true even in the face of energy shortages now being experienced.

PLASTIC WASTE GENERATION FROM PACKAGING AND NONPACKAGING SOURCES

Introduction

Plastic packaging materials are used in a wide variety of consumer and industrial markets. We have assumed that essentially all packaging materials enter the waste stream within 1 year after they are manufactured or produced, since by their nature, they are manufactured and sold as "disposable" items. Although some items such as containers are used around the home for storage, decoration or other purposes, the quantity is believed to be minor in relation to all plastics waste.

It should be noted that although packaging wastes account for the major portion of plastic waste generation, housewares, toys and other disposable items account for a substantial portion. A study by Arthur D. Little, "Incentives for Recycling and Resue of Plastics,"[80] showed that 71 percent of the plastic consumer waste consists of packaging materials in 1970. They predict that this will decline to 67.5 percent in 1975 and 65 percent in 1980. Assuming that the decline in the percentage of packaging is constant throughout the period, this would result in the 1972 plastic waste generation being composed of 69.5 percent packaging. Consequently, total plastic waste generation in municipal waste was 4.25 million tons in 1972 (Table 78). We have assumed that between 1980 and 1990, the ratio will have reversed and returned slowly to 69 percent packaging wastes and the balance nonpackaging. In addition, there is another 250,000 tons estimated plastics waste generated in discarded appliances, furniture and similar bulky items. In total then, plastic waste generation would be 4.5 million tons in 1972, increasing to 13.2 million tons in 1990 (in municipal solid waste).

Litter: According to a survey of roadside litter conducted by Research Triangle Institute[31], there were 650 million plastic items littered during 1969. Although this is a large number of items, there is no estimate of the weight of the plastic in the litter. We have assumed that it is less than 1 percent of all plastic packaging and will remain at that low level, although the use of plastic beverage containers after 1980 could lead to a significant increase in bittered plastic items.

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* Aluminum packaging will also increase in use rapidly in this period.

TABLE 78

PLASTIC WASTE GENERATION IN MUNICIPAL WASTE, 1972 TO 1990

(In thousand tons)

Type of Plastic Waste	1972	1975	1980	1985	1990
Packaging	2,959	3,693	5,300	7,100	8,900
Nonpackaging	1,291	1,757	2,850	3,650	4,050
Other	250	250	250	250	250
Total	4,500	5,700	8,400	11,000	13,200

Source: Midwest Research Institute.

WASTE GENERATION FROM PLASTIC PACKAGING

Plastic Packaging Waste Generation by Source

Plastic packaging materials will appear as waste from households and apartments as a result of their use by the consumer; from commercial and institutional establishments as the result of purchases by individuals and organizations; and from industrial sources as the result of products for general industrial maintenance, waste bag liners and pallet wrap.

An estimated 2.47 million tons of plastic packaging waste was generated from households in 1972. This is equivalent to 83.6 percent of all plastic packaging waste. Commercial and institutional waste amounted to 286,000 tons (916 percent) while industrial waste generated was 202,000 tons (6.8 percent) (Table 79).

Film: Approximately 80 percent of the packaging film appears as household waste with the balance divided equally between commercial-institutional and industrial waste. Household wastes include discarded food wraps and bags, garment bags, trash bags and various consumer products wrapped in film or packed in bags. Commercial-institutional uses include the above items along with waste pallet wrap and trimmings from film used to package consumer items (e.g., supermarkets). Industrial wastes include liners in discarded shipping bags, pallet wrap, other industrial wraps and wastes from trimming and cutting film for packaging.

TABLE 79

PLASTICS PACKAGING WASTE GENERATION BY SOURCE, 1972
(In thousand tons)

Plastic End Use	Household		Commercial & Institutional		Industrial		Total
	Tons	Percent	Tons	Percent	Tons	Percent	Tons
Film	1,132	80	142	10	142	10	1,416
Miscellaneous Packaging	545	85	64	10	32	5	641
Blow Molded Containers	412	90	23	5	23	5	458
Coatings	297	85	52	15	--	--	349
Closures and Caps	85	90	5	5	5	5	95
Total	2,471	83.6	286	9.6	202	6.8	2,959

Source: Midwest Research Institute estimates.

Because of the rapid growth of pallet wrap and industrial shipping bags, a greater percentage of waste will come from industrial firms in the future. By 1990, industrial uses of plastic will lead to generation of 15 percent of all film waste. Household film waste will decline to 75 percent of the total.

Miscellaneous packaging: Miscellaneous packaging wastes are predominantly household wastes (85 percent of the total). Commercial-institutional wastes account for 10 percent with the balance appearing as industrial waste. Household wastes include discarded food containers, boxes, trays, foamed cups, single service dinnerware and foamed packaging inserts. Commercial-institutional wastes include the above items, along with beverage cases and pallets. Industrial wastes are mostly foamed packaging, discarded pallets and a small quantity of food containers.

Because of the predicted rapid growth for institutional and single service dinnerware, the commercial-institutional waste will increase to 20 percent of the total by 1990, while household waste will decline to 75 percent of the total.

Blow molded containers: Blow molded containers are used to package a wide variety of consumer items. We estimate that their waste disposal patterns are the same as glass containers because their uses are much the same as glass, e.g., to package food products and beverages. Household waste accounts for 90 percent of the containers and the balance is divided between commercial-institutional and industrial wastes. Household chemicals and cleaners, toiletry and cosmetic products, milk containers, medicinal and health products, and food containers represent household waste. A portion of these containers are also discarded at commercial and institutional facilities by employees and residents. About 4 percent of the containers are filled with industrial products such as oils, cleaners and chemicals.

Household and commercial-institutional wastes from discarded blow molded plastic containers will increase more rapidly than industrial wastes in the future because of the development of the all-plastic beverage container.

Coatings: Coated paperboard, paper and foil wastes are estimated at 85 percent household and 15 percent commercial-institutional waste. Coated milk cartons account for half of the use of coatings. No change is anticipated in this ratio in the future.

Closures and caps: Closures and caps parallel blow molded container use where 90 percent appear as household waste with the balance divided among commercial-institutional and industrial wastes. No developments are anticipated that will change this ratio in the future.

The results show that future waste generation from commercial-institutional and industrial sources will become a greater percentage of all plastics packaging wastes (Table 80)*.

PLASTIC PACKAGING RECOVERABLE FROM WASTE

Plastics packaging waste recovery estimates were developed by assuming that the population within standard metropolitan statistical areas (SMSA's would be large enough to economically support recovery). No separate collection of plastics is likely to occur.

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* Our in-depth study excluded nonpackaging and other plastic wastes. We can only estimate that discard patterns for these plastic products follow a similar pattern to that of plastics packaging wastes as described. However, we have no firm basis for this estimate.

TABLE 80

PLASTICS PACKAGING WASTE GENERATION BY SOURCE, 1972-1990
(In thousand tons)

Waste Source	1972		1975		1980		1985		1990	
	Tons	Percent	Tons	Percent	Tons	Percent	Tons	Percent	Tons	Percent
Household	2,471	83.6	3,040	82.3	4,267	80.5	5,610	79.0	6,910	77.7
Commercial and Institutional	286	9.6	373	10.1	573	10.8	810	11.4	1,060	11.9
Industrial	202	6.8	280	7.6	460	8.7	680	9.6	930	10.4
Total	2,959	100.0	3,693	100.0	5,300	100.0	7,100	100.0	8,900	100.0

Source: Midwest Research Institute

Using the ratios developed in Chapter V for allocating household, commercial/institutional and industrial waste to SMSA's, the waste generation derived is shown in Table 81.

TABLE 81

PLASTIC WASTE GENERATION IN SMSA's, 1972-1990
(In thousand tons)

Plastic Waste Source	1972	1975	1980	1985	1990
Household (packaging)	1,700	2,110	3,000	4,020	5,020
Commercial/Institutional (packaging)	210	280	440	620	830
Industrial (packaging)	130	185	300	460	635
Total Packaging	2,040	2,575	3,740	5,100	6,485
Nonpackaging plastic	890	1,220	2,010	2,620	2,950
Other plastic	170	175	175	180	180
Total All Sources	3,100	3,970	5,925	7,900	9,615

Source: Midwest Research Institute.

PLASTICS RECOVERY FORECASTS, 1972 TO 1990

Plastic Packaging Recovery, 1972

In-plant recycling of plastics has been practiced by the industry from its inception. Approximately 1.2 billion pounds of scrap plastic from manufacturing, fabricating and converting were recycled in 1972.80/

Scrap plastic is available from all phases of the manufacturing cycle. Scrap may be generated from resin manufacture, compounding, fabrication, and converting. The scrap generated may be as low as less than 1 percent of the virgin resin to as high as 50 percent, depending upon the process and product manufactured. Scrap may be in the form of off-grade resin, trimmings, strands or large chunks. The resin is usually reground and combined with virgin resins, or fabricated into products which can tolerate a wider range of performance properties. The scrap may be used by the manufacturer or sold to an independent compounder or reprocessor who often will remove contaminants from the scrap before reselling to fabricators.

However, recycling of post-consumer plastic waste has been insignificant. Attempts have been made to recycle plastic containers such as milk bottles and other blow molded containers. A few dairies have been collecting containers from their home delivery routes and regrinding them for sale to reprocessors and fabricators. Most have found this no better than a break-even proposition since they have experienced a relatively low return of the containers from their routes.

Seajay, Inc., of New Shrewsbury, New Jersey, has established a volunteer recycling center.104/ Plastic bottles are delivered to this plant where they are hand sorted and reground. The plastic waste is sold to a molder who mixed it with virgin resins for blow molding into a variety of products.

With the exception of the industrial recycling of scrap plastics, no other recycling efforts of any significance are conducted at the present time. Volunteer collection systems are negligible today and are not projected to become a factor in the future because of the low value of the plastic waste and the fact that plastics must be separated by resin type before they can be considered for significant reuse by the reprocessor. Thus, if plastics from consumer waste are to be recycled, they must come from resource recovery systems in major metropolitan areas.

Recovery of Plastics from Municipal Waste, 1972-1990

There are no commercial systems in existence that are recovering plastics from mixed municipal refuse. It is also doubtful that an economically viable system will be developed in the next decade. The technology of most resource recovery systems consists of shredding the incoming waste followed by air classification to remove the inorganic wastes, glass and magnetic separation to remove ferrous metals, nonferrous metals for eventual recovery. The remaining (organic) fraction consisting of paper, plastics and other fibrous materials would have to be further processed to separate the plastics from the paper. Even if a fraction rich in plastics were separated from the paper, only limited recycling uses exist for mixed post-consumer waste plastics. The plastic fraction would contain a wide variety of polymers which would be extremely difficult to distinguish for separation.

Attempts have been made to manufacture products from mixed plastics. They usually result in items with poor physical properties that are porous and brittle. A recent Dow Chemical patent uses chlorinated polyethylenes to blend with mixed resins to attempt to improve the physical properties.[80] Through evaluation, they found that these resins could have application for manufacturing tiles, pallets, toys, and construction materials. This was a very limited study and the process it examined is not yet commercial.

Research is being conducted on methods for separating plastics from mixed municipal waste. The Bureau of Mines has established a resource recovery system to recover metals, glass, paper, plastics, aluminum, copper and zinc.[83] This process begins with a coarse shredding, followed by removal of the iron by magnetic separation and air classification to separate the light fraction from glass and large nonferrous metals. The light fractions are shredded further and again air classified to separate the remaining metals, fine glass, plastics, rags, putrescible material, heavy paper and cardboard from the lighter paper and plastic fraction. The heavy fraction is further classified to remove plastics and putrescibles and to separate the heavier materials into a fine glass product and metal composite. The light fraction from each of the air classifiers is combined and treated in another separator to yield a composite product of various plastics and mixed papers.

The Black Clawson system in Franklin, Ohio, could possibly recover plastics. This system, previously discussed, uses a hydropulper to reduce the material size in a liquid system. The slurry which contains paper, textiles, leather, plastics, and other fibers, passes through a primary fiber selector to remove the long fine fibers which are dewatered, baled and shipped to a roofing mill. The rejected material is fed to a secondary fiber selector to remove the intermediate length fibers which are dewatered, and baled. The remaining fraction contains mostly textiles, leather, plastics and some paper fibers. Black-Clawson claims that additional screening of this fraction could remove the very fine fibers and some organic residue to produce a highly enriched plastic waste fraction which could be further separated to remove the plastics. However, they do not have any plans at the present time to separate the plastics which are being burned in a fluid bed incinerator.

Although research and development will continue on methods for separating plastic waste from mixed municipal waste, we do not believe that plastics will be recovered for their materials value from resource recovery systems before 1990. Technology and economics would dictate that they would have to be part of a system that would recover paper, glass and ferrous metals. The cost of recovery would far outweigh any potential income from the recovered material. Even if plastics were recovered, it is doubtful that markets would exist because of the low quality and wide variety of plastics in the waste.

Recovery Forecast for Plastics, 1972 to 1990

The most likely method of recycling plastic wastes will be through energy recovery systems where the fraction consisting of paper, plastics, garbage, yard wastes, leather and other organics is burned to recover the heat value.

Most plastics have a heat value equivalent to a high grade of fuel oil, since they are themselves derivatives of hydrocarbons. Polyethylene has a heat potential of 18,000 Btu per pound and PVC has a heat potential value of 9,500 Btu per pound. This high heat value tends to raise the Btu value of the total waste fraction, improving its burn-ability and use as a energy source in resource recovery.

In the foreseeable future, energy recovery (see Chapter III) is the most viable option for post-consumer plastic waste. There may be limited recycling of post-consumer plastics, but for the most part, we do not feel that recovery of plastics in this manner will develop.

We have assumed that energy recovery from plastics will be a part of the forecast of centralized recovery systems to be installed. Thus, the plastics will be processed for their heat value in proportion to total occurrence in municipal waste. Our forecasts for recovery are in Table 82. The plastics content of waste will rise from 3.5 percent in 1972 to 6.6 percent in 1990. The amount of plastics processed through central energy recovery systems will rise from none in 1972 to 3.2 million tons in 1990; this is 96.3×10^9 Btu "higher heating value" content recovery in 1990 (i.e., without adjustment for thermal efficiency or losses).

Resource recovery will have little effect upon the solid waste load from plastics. The rapid growth in the use of plastics will cause the net plastic waste disposal (generation minus recovery) to increase from 4.5 million tons in 1972 to 8.4 million tons in 1980 and 10.5 million tons in 1990. Thus, the growth of tonnage will be slowed, but not stopped, by resource recovery installations. On an SMSA basis, the net disposal will rise from 2.9 million tons in 1972 to 5.4 million tons in 1980 and 7.5 million tons in 1990 (Table 82).

By 1990, 24.3 percent of the total plastic waste generation will be recovered for its energy content (33.3 percent of that generated in SMSA's). Thus, while recycling of plastics appears to have dim prospects, the recovery of the energy content will be significant.

TABLE 82

PLASTICS RECOVERY FROM MIXED MUNICIPAL WASTE, 1972 TO 1990

(In thousand tons)

Category	Year 1972	 1975	 1980	 1985	 1990
Total Mixed Waste Generated	130,000	140,000	160,000	180,000	200,000
Plastics Available in Municipal Waste	4,500	5,700	8,400	11,000	13,200
Percent Plastic in Waste	3.5	4.1	5.3	6.2	6.6
Number of Resource Recovery Plants Recovering Energy	None	5	12	32	60
Total Mixed Waste Processed in Central Facilities	None	2,100	6,600	24,000	48,600
Total Plastics in Processed Waste	None	85	350	1,470	3,210
Recovery-10^6 Btu (at 30 × 10^6 Btu/Ton a/)	Neg.	2,550	10,500	44,100	96,300
Plastics Available in SMSA's	3,100	3,970	5,925	7,900	9,615
Plastics Recovery (as energy) as a percent of:					
Total Plastic waste	0	1.5	4.2	13.4	24.3
Plastic Waste in SMSA's	0	2.1	5.9	18.6	33.3

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a/ The Btu value and recovery percentage is based on 100 percent of the Btu content (higher heating value) and not the heat (as work) actually delivered considering thermal efficiency.

Source: Midwest Research Institute.

CHAPTER IX

RECOVERY FORECASTS FOR RUBBER TIRES TO 1990

SUMMARY

The demand for rubber tires of all types will increase from 230 million units in 1972 to 375 million units in 1990. This includes original equipment as well as replacement tires. In 1972, about 127.5 million tires were discarded which is about 1.6 million tons of tire waste; by 1990, there will be 223 million tires discarded or 3.1 million tons of waste. These are the net discards after allowance for retreading, reclaiming and tire splitting.

There will be, over time, a general increase in the strength and quality of passenger car tires, as a result of use of new fibers, increasing use of radial tires and stiffer safety standards. If raw materials come into short supply, there may be, in addition, a return to more extensive retreading of auto tires just as truck and bus tires are handled today.

Although most tires sold are for private passenger cars, they do not show up in household waste as discards. Instead, almost all of the tires are traded in to wholesale and retail dealers. We estimate about 95 percent of all tires are discarded as commercial/institution waste--1.5 million tons in 1972, and 3.0 million tons in 1990.

Of the total 1.6 million tons of tire waste discarded in 1972, about 1.2 million tons will be available in SMSA's. By 1990, there will be 2.4 million tons available in SMSA's compared to 3.1 million tons total waste generated.

Only two recovery activities will be significant by 1990 as far as the use of rubber tires is concerned--retreading and energy recovery. Retreading will begin to rise in importance again after 1980.

The development of pyrolysis furnaces to handle whole tires economically (and without air emission problems) will lead to significant energy recovery from tires, principally for process steam. Tires contain the heat value of a high grade coal, 25 million Btu per ton. We forecast that in 1985, 22,000 tons of tires will be processed for energy recovery, generating 0.6×10^9 Btu; by 1990, 400,000 tons of tires will be processed for 10×10^9 Btu. On a percentage basis, this is 12.9 percent of all waste tires in 1990 and 16.5 percent of that generated in SMSA's. For the most part, the energy recovery will take place in special recovery furnaces rather than as a integral part of centralized resource recovery systems. However, if a low cost mechanical shredding system comes into use, tires may be aggressively sought as an energy source, because of their high Btu content. In fact, there are some indications our forecasts of tire recovery could be very conservative.

INTRODUCTION

In 1972, tires made up 65 percent of the total rubber demand in the USA; rubber mechanical goods were 17.5 percent; other uses were 17.5 percent (see Table 83). Of these products, the ones of significance in municipal waste are: tires, footwear, and foam. The balance is largely associated with industrial, farming, and transportation. Total new rubber demand in 1972 was 3.0 million tons.

TABLE 83

DEMAND FOR NEW RUBBER BY END USE CATEGORY, 1972
(In Thousand Tons and Percent)

End Use Category	Quantity	Percent
Tires and Tire Products	1,980	65.0
Mechanical Goods	530	17.5
Other Rubber Products	210	7.0
Footwear	180	6.0
Latex Foam Products	100	3.5
Wire/Cable	30	1.0
Totals	3,030	100.0

Source: Rubber Manufacturers Association.

The use of rubber in tires has run close to 65 percent of total rubber demand for several years. This relationship is likely to continue, even with the trend toward longer life tires.

RUBBER TIRE DEMAND BY MARKET, 1962 TO 1990

Forecast of Total Tire Demand to 1990

Demand for tires has increased steadily over the past 10 years. The outlook is for a steady but small annual increase in tire demand through 1990. Passenger car, truck and bus tire shipments in 1962 were approximately 130 million units. This figure increased to approximately 213 million units in 1972 (or about one tire per person per year for the USA).

The annual demand for tires is determined by the number of cars, trucks, and buses that will be in service during the period in question and the mileage driven. By 1990, approximately 190 million vehicles will be in service, up from approximately 120 million cars, trucks, and buses now registered. With this predicted growth in vehicle registration, there will be an increased demand for tires in direct proportion to the increasing number of vehicles registered.

Considering this indicator, industry experts predict passenger car tire shipments in 1990 will be 320 million units compared to 196 million units shipped in 1972. Truck and bus tire shipments will be 55 million units in 1990, up from 34 million units shipped in 1972 (Table 84 and Figure 26).

These forecasts were made under the following assumptions: None of the EPA proposals banning automobiles from metropolitan streets will become law; the current shortage of motor fuel will not continue over a long period of time and motor fuel will be available at a price that does not depress travel significantly[*]; the automobile will remain the primary source of transportation through 1990; the radial tire will not be used on more than 50 percent of new cars and will not exceed 40 percent of the replacement tire market.

Tire Construction Trends

There are now three principal tire construction types--the bias ply, the bias belted and the radial tire. What their use trends will be in the late 1970's and the decade of the 1980's is not yet determined.

Many rubber industry experts consider the radial tire too expensive to outsell the bias belted tire. The reason given for this is that drivers in the United States do not need a tire of the radial's capabilities

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[*] Or power plants, auto design and other energy conservation design parameters will lead to reduced demand for motor fuel relative to "normal growth" in total vehicle registration.

TABLE 84

TIRE SHIPMENTS BY VEHICLE TYPE, 1962 - 1990

(In Million Units)

Year	Passenger Car Tire Shipments			Truck and Bus Tire Shipments		
	OE[1]/	Replacements	Total	OE[a]/	Replacement	Total
1962	37.5	78.4	115.9	4.5	10.6	15.1
1964	41.9	79.0	120.9	5.5	12.1	17.6
1968	49.9	121.1	171.0	8.5	16.3	24.8
1971	49.0	136.0	185.0	10.0	18.3	28.3
1972	54.0	142.0	196.0	13.0	21.0	34.0
1975	58.0	175.0	233.0	15.0	25.0	40.0
1980	66.0	195.0	261.0	17.0	30.0	47.0
1985	73.0	215.0	288.0	19.0	32.0	51.0
1990	80.0	240.0	320.0	20.0	35.0	55.0

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a/ Original Equipment

Source: Rubber Manufacturers Association (1962-1971); Midwest Research Institute forecasts.

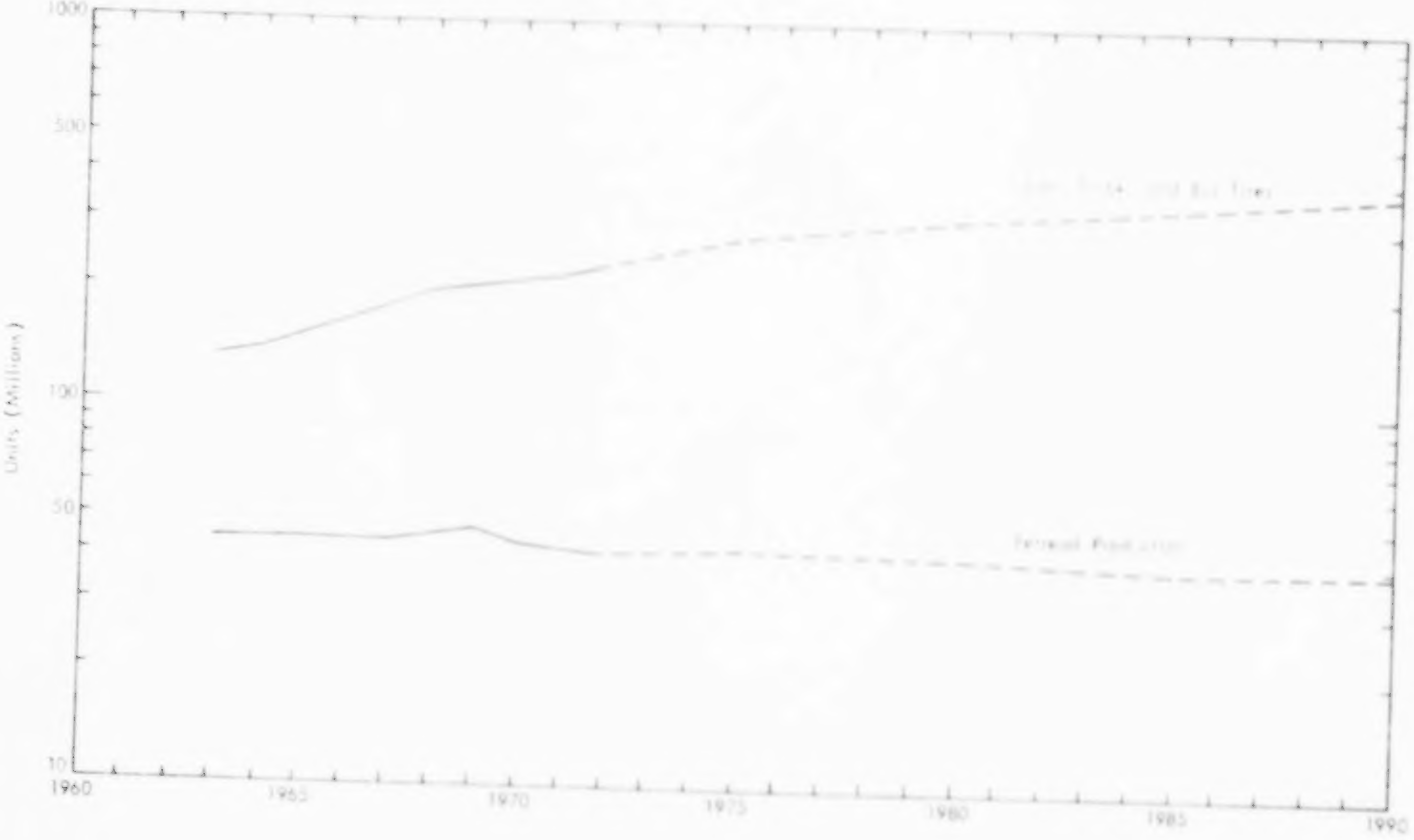


Figure 26 - New Tire Shipments and Retread Tire Production, 1962-1990

just to drive the family car to the store or to work, and therefore, will not pay the higher price of the radial. Instead, consumers will likely prefer bias belted tires. MRI, based on literature sources, has projected the bias ply tire to all but disappear by 1990; the bias belted tire to hold about 60 percent of the business and radial tires to have about 40 percent of the total tire market (Table 85).

TABLE 85

PASSENGER CAR TIRE MARKET SHARE BY TYPE OF CONSTRUCTION, 1972 - 1990
(In percent)

Year	Type Construction	Original Equipment	Replacement
1972	Bias Ply	16	52
	Bias Belted	78	41
	Radial	6	7
1975	Bias Ply	10	46
	Bias Belted	59	33
	Radial	31	21
1980	Bias Ply	5	30
	Bias Belted	60	45
	Radial	35	25
1985	Bias Ply	2	15
	Bias Belted	60	55
	Radial	38	30
1990	Bias Ply	--	10
	Bias Belted	60	60
	Radial	40	30

Source: Rubber Manufacturers Association, 1972, Midwest Research Institute, 1975 to 1990.

In addition to the trend to radial and bias belted tires, the type of tire cord used in tire construction is likely to change in the future. The cord is one of the key components of a tire that determines its structural integrity and durability.

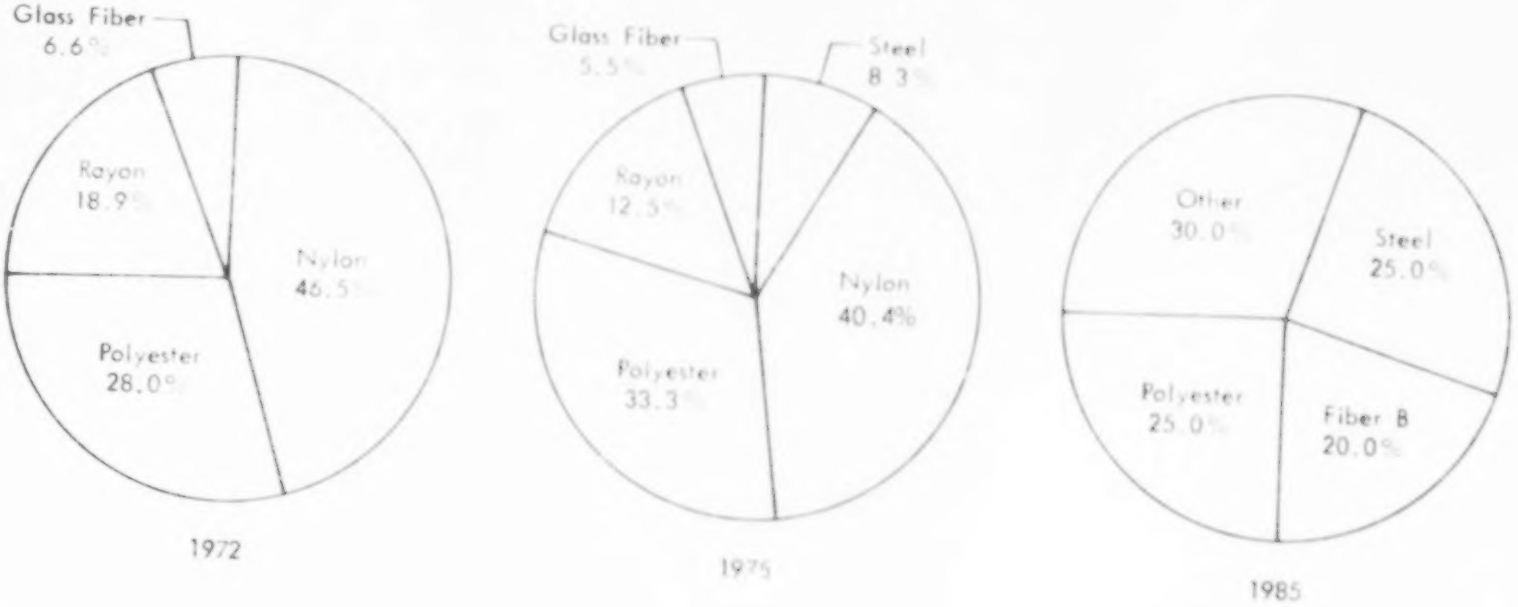
Tire cord requirements will change over time as indicated in Figure 27. The present profile shows nylon with 46.5 percent of the total, polyester 28 percent and rayon 19 percent. By 1975, it is expected that glass, rayon and nylon fibers will have declined in use while polyester will rise to one-third and steel will have increased to 8 percent of the tire cord market. Under these trends, by the early part of the 1980's, rayon and nylon cord will be completely replaced by other fibers except in the case of a few specialty tires; polyester will be about one-fourth; steel, one-fourth; and new synthetic fibers will gain about one-fifth of the total cord market. Steel cord is now displacing glass fiber as a tire cord material. Glass fiber will likely take a lower share of the market but not disappear. Also, polyester will continue to hold a large share of the original equipment market until 1975, according to industry sources. Rayon and nylon, which have been in use as tire cord for years, are expected to decline in importance beginning by 1974 or 1975, and by early in the next decade, will have been displaced completely by polyester, steel and other new fibers.

With the new stronger tire cords and especially the stronger, safer tire carcasses starting to appear in mass-produced quantities on the market, it is possible that tire retreading could be rejuvenated. This may lead to extending the life of tires via a retreading cycle similar to that used commonly for trucks and [illegible]. This could become a viable alternative to disposal of passenger car tires, although retreading as a common practice must be considered speculative at this time.

Waste Generation from Discarded Tires

The forecast increase in the number of tires to be used is of special concern because of the difficulty of disposing of discarded tires. In landfills, tires cannot be effectively compacted and even when buried, tend to work their way to the surface over a period of years. In addition, tires use a large volume of landfill space. Tires cannot be handled efficiently in conventional incinerators.

One method of disposing of discarded tires is shredding, splitting or otherwise reducing the volume of the tire. However, these types of operations are few in number and high cost; shredding is used only in a very few locations in the country. One special furnace to pyrolize old tires has been built in Jackson, Michigan; the unit will produce steam for plant use, but the operating history is too short to determine whether this resource recovery approach is commercially viable. Another experimental plant is scheduled to be built in the Denver area.



SOURCE: Rubber Manufacturers Association (1972)

Figure 27 - Tire Construction by Tire Cord Type (1972, 1975, 1985)

Calculating the total waste generated from tire discards is relatively straightforward. The number of tires entering the waste stream should equal the number of replacement tires purchased in a given year, less tires recapped and reclaimed for other uses.

Three types of tire recovery take place that reduce the total discard of old tires--retreading, tire splitting, and rubber reclaiming. These are operations that have been in decline for many years. The trend in tire retreading is given in Table 86. In 1972, the retreading rate for passenger car tires was 22 percent of new replacements and truck and bus tire retreading was 45 percent of new replacements.

TABLE 86

TIRE RETREADING, 1963 - 1972
(In millions of units)

Year	Passenger Car Tires	Truck and Bus	Total
1963	36.3	7.5	43.8
1965	36.0	7.6	43.6
1967	34.5	9.3	43.8
1969	36.5	10.0	37.5
1971	31.8	10.7	42.5
1972[a]	31.2	9.5	40.7

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[a] Based on 6 months' data
Source: Rubber Manufacturers Association.

The declining rate of retreading in passenger car tires is expected to continue until 1980; after this, we have forecast an increase in retreading, although not a dramatic one (Table 87). If a severe shortage of hydrocarbon feed stocks develops for synthetic rubber, the rate of retreading could rise dramatically.

The net waste generation of tires was also calculated. In total, 122.5 million units are estimated to have been discarded in 1972 or 1.8 million tons; by 1990, the net discard rate will be risen to 223 million units and 3.4 million tons. From these figures, the amount of reclaimed rubber and rubber splitting use must also be deducted.

The reclaimed rubber industry, which converts used rubber products into reuseable materials, has experienced a production decline since 1963.

TABLE 87

WASTE GENERATION FROM TIRE DISCARD, 1972 TO 1990

(In Million Units and Million Tons)

Year	Passenger Car Tires Replacements	Retreads	Net Discard	Quantitya/	Truck and Bus Tires Replacements	Retreads	Net Discard	Quantityb/
1972	141	31	111	1.4	21	9.5	11.5	0.4
1975	175	31	144	1.8	25	10.0	15.0	0.6
1980	195	30	165	2.1	30	10.5	19.5	0.7
1985	215	35	180	2.3	32	11.0	21.0	0.8
1990	240	40	200	2.5	35	12.0	23.0	0.9

Year	Total Net Discards	Quantity	Adjustmentc/	Discarded Net Quantity
1972	122.5	1.8	0.2	1.6
1975	159.0	2.4	0.2	2.2
1980	184.5	2.8	0.2	2.6
1985	201.0	3.1	0.2	2.8
1990	223.0	3.4	0.3	3.1

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a/ At 25 pounds per tire total weight of rubber, cord etc., in tire.
b/ At 75 pounds per tire total weight of rubber, cord etc., in tire.
c/ Rubber reclaim and tire splitting rubber recovery.
Source: Midwest Research Institute estimates.

Reclaimed rubber consumption as a percent of total new rubber has declined from approximately 15 percent in 1963 to 10 percent in 1968 and 7 percent in 1972. We estimate that reclaimed rubber production will level off between 4 percent and 5 percent of new rubber through the 1972-1990 period.

The tire splitting industry is the only rubber waste user predicting a possible increase in production. However, today there are only three companies in business and tire splitters do not process enough rubber waste to be considered a significant waste processer when the total tire waste rate is considered. Estimates are that these three companies process only 1 percent of the total number of discarded tires and thus, do not significantly reduce rubber tire waste.*

Based on these estimates, we have further reduced net waste generation by an estimated 200,000 tons per year in 1972 to 300,000 tons in 1990 (Table 87).

Overall, therefore, it is estimated that in 1972 approximately 1.6 million tons of tires entered the waste stream for disposal; by 1990, this total will have risen to 3.1 million tons (Table 87).

TIRE WASTE GENERATION BY SOURCE

Tire Waste in Household, Commercial/Institutional and Industrial Wastes

Approximately 80 percent of the total vehicles on the road are considered noncommercial.** This percentage has remained stable over the past few years.

However, because of the nature of the tire business, almost all replacement tires are sold via wholesale and retail stores and this is where the waste tires accumulate. Therefore, those that do not find their way to rubber reclaimers or tire splitters end up as waste in the commercial sector. For these reasons, we have placed almost all tire discard tonnage in the commercial/institutional waste stream, even though their useful life is served out in other places. We estimate that 4 percent of tire discards are in the industrial sector and less than 1 percent discarded from households. The discard profile by waste source is given in Table 88.

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* "Rubber Reuse and Solid Waste Management," Environmental Protection Agency, 1972.

** Source: Automobile Manufacturers Association.

TABLE 88

TIRE WASTE GENERATION BY SOURCE, 1972 TO 1990

(In thousand tons)

Year	Tire Waste Generated	Household Waste Generation	Commercial/ Institutional Waste Generation	Industrial Waste Generation
1972	1,600	10	1,525	65
1975	2,200	10	2,100	90
1980	2,600	15	2,480	105
1985	2,800	15	2,670	115
1990	3,100	15	2,960	125

Source: Midwest Research Institute.

Tire Wastes in Litter

We have no firm estimates for tires found as uncollected litter. It is known that tires are thrown along road sides, into water bodies, discarded in camp grounds and on private property; additionally, tires in uncollected abandoned vehicles could be considered as litter. We have arbitarily estimated that litter would claim about 1/2 percent of the net tire waste generated. This would be 8,000 tons in 1972, rising to 13,000 tons in 1980 and 15,000 tons in 1990. Since these are speculative numbers, we present them merely to acknowledge the existance of uncollected tires as litter.

Tires Recoverable From Waste

Today tires are virtually worthless for any form of recovery if they are not already acceptable as retreads or for reclaimed rubber. Some are used for offshore reef building in fishing areas. Others are ground up for use in rubberized asphalt compounds. However, for the most part, tires entering the waste stream have no economic value.

To calculate recoverability, we limit the prospective collection system to SMSA's as we did for other waste materials. The quantity of waste generation in SMSA's was calculated from the ratio of commercial/institutional wastes given in Table 89.

Tires and other tire products are collected and accumulated mainly by retail tire stores, gasoline stations and other similar retail outlets.

TABLE 89

SUMMARY OF ENERGY RECOVERY FORECAST FOR TIRES IN MUNICIPAL WASTE, 1962 to 1990
(In thousand tons and percent)

Year	Total Generated	Energy Content 10^9 Btu	Generated in SMSA's	Energy Content 10^9 Btu	Processed for Energy Recovery	Energy Recovery 10^9 Btu	Recovery as a Percent of Total	Recovery as a Percent of SMSA's
1972	1,600	40	1,185	30	None	0	0	0
1975	2,200	55	1,645	41	22	6.0	1.0	1.3
1980	2,600	65	1,980	50	100	2.5	3.8	5.0
1985	2,800	70	2,160	54	200	5.4	7.1	9.3
1990	3,100	78	2,430	61	400	10.0	12.9	16.5

Source: Midwest Research Institute estimates.

Few tires are actually placed in the waste stream by the consumer. This practice normally results in tire accumulations at convenient pick-up points and then they are taken to a dump in large amounts.

From this, it can be assumed most used tires that have been replaced can be easily collected for reuse and do not have to be separated from other residential waste as is the case with most materials. We have estimated that 95 percent of all discarded tires in SMSA's are available for collection and recovery.

In 1972, a total of 1.2 million tons of tires as waste were generated in SMSA's; by 1990, this total will rise to 2.4 million tons (Table 89). Estimating that 95 percent of this could actually be delivered to a recovery site, the potential recovery of tires as waste would be 1.1 million tons in 1972 and 2.3 million tons in 1990.

Trends in Rubber Tire Recovery

The use of rubber tires for retreading, reclaiming and tire splitting has been discussed previously. These fractions have been shown as a net deduction from total tire discards. Whether retreading might regain more popularity for passenger car tires is now questionable. With today's technology, safe retreads can be manufactured, but tire companies must revive the retread in consumer tire markets--including quality and performance specifications. At the present time, a turn by the tire companies to this idea does not seem to be forthcoming, although a shortage of raw materials could set the practice back "in vogue" quickly.

In the past several years, there have been several new techniques developed that could possibly solve some of the present problems involved in processing used tires.

Using old tires to construct artificial reefs has been suggested in response to the growing popularity of sport fishing off the Gulf and Eastern coasts. The main problem with this approach is that water action must be fairly weak or the reef cannot be constructed in the proper method. Also, there are no extensive data as to the costs and benefits that are involved in using these reefs as fish spawning points.

Another possible way to dispose of shredded tires is by mixing the ground rubber with asphalt as a binder. It is reported that rubber reduces the tendency of asphalt to "bleed" and, in turn, cause a skidding hazard. However, at present, the cost of adding rubber to roads is very high in most cases. This cost could be incurred by many states and cities if it is shown that this procedure reduces the need for road maintenance. At present, New York and Arizona are conducting experiments in this area.

However, the most viable recovery option is the energy value of tires, converted in pyrolysis furnaces for the generation of process steam. Goodyear has a Lucas (English) furnace in operation at Jackson, Michigan, to pyrolize tire carcasses and generate steam. However, no operating data are yet available on the process. The technology and economics are unknowns but appear promising. We estimate that by 1990 perhaps 13 percent or 400,000 tons of old tires will be processed for energy recovery in two types of installations--those in conjunction with centralized waste processing units and those designed to serve industrial plants with process steam. However, our estimates cannot be derived from a firm base at this point in time, except from the fact that tires are hydrocarbon-based and represent a very attractive energy source given a reliable, low cost conversion technology. Our projections for tire recovery in energy installations is summarized in Table 90. Although other recovery options could arise, we believe recovering the energy content of discarded tires will be the most viable even if increased retreading does become a significant factor also.

The heat content of tires is 12,500 Btu/pound or 25 million Btu/ton;* this is equivalent to coal. In fact, tires have a higher Btu content than the low sulfur Wyoming coal now being purchased in quantity by utilities.

The potential energy recovery from waste rubber tires generated in SMSA's is also given in Table 89. The actual recovery will be modest amounting to 0.6 x 10^9 Btu in 1975 and 10 x 10^9 Btu by 1990. This is 12.9 percent of total tire waste in 1990 and 16.5 percent of that generated in SMSA's. For the most part, this recovery will take place via special pyrolysis units and will produce process steam for a resource recovery plant or local industrial use.

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* "Rubber Industry and the Environment" Rubber World, December 1973, pages 53-54.

CHAPTER X

RESOURCE RECOVERY FOR PAPER TO 1990

INTRODUCTION AND OVERVIEW

Paper is the major component of solid waste, and has several recovery options that will be pursued in the future. Paper will increase in importance as a recycled material; as an export to fiber short countries; and as an organic it has fuel value for energy recovery options. It is also usable as a fiber source for other products.

The demand for paper products is forecast to increase steadily to 1990, which means an increasing rate of waste generation. However, recycling of paper will also increase substantially in the future, and the advent of energy recovery on a large scale as forecast in Chapter II will mean useful recovery of a significant portion of that paper not recovered for recycling purposes.

Our forecasts show that 1973 was the "turnaround" year for resource recovery of paper. The rate of paper recycling increased in 1973 after three decades of relative decline, and recycling likely will continue to rise in the years to follow. However, the rate of growth of recycling will flatten as the industry begins to expand its virgin fiber processing capability more rapidly in the late 1970's. Further, the forecast recycling rate is below the potential rate if more favorable economic conditions preferentially encourage investment in recycling facilities.

The overview of our forecasts for the period 1972 to 1990 is given in Table 90. We have forecast an increase in demand from 64.4 million tons in 1972 to 109.2 million tons in 1990. At the same time, recycling of waste paper will increase from 12.9 million tons in 1972 to 27.1 million tons in 1990. This means an increase in the rate of recycling in the paper industry from 20.1 percent in 1972 to 24.8 percent in 1990. In addition, net exports of waste paper and use of paper in other products is expected to draw another 1.9 million tons from the waste stream in 1990. Above this, solid waste-based energy recovery systems will utilize 15.3 million tons of paper by 1990, compared to virtually none in 1972 (Figure 28).

Thus, the total useful recovery of paper will stand at 44.4 million tons in 1990, compared to 13.6 million tons in 1972, a 226 percent increase. This recovery rate will be 40.6 percent of demand and 47.4 percent of waste paper generated.

TABLE 90

SUMMARY OF RESOURCE RECOVERY FORECASTS FOR PAPER, 1972-1990

(In thousand tons)

Category	1972	1975	1980	1985	1990
Total USA Paper Demand	64,400	66,490	79,360	93,565	109,240
Total Waste Paper Generation	55,050	56,950	68,950	79,950	93,650
Source of Waste Paper--					
Household	25,000	25,500	30,000	33,650	38,300
Commercial/Institutional	24,300	25,450	31,650	37,750	45,350
Industrial	5,750	6,000	7,300	8,550	10,000
Waste Paper Recovery: a/					
For Recycling by Paper Industry	12,932	13,960	17,610	22,215	27,090
For Use in Molded Pulp Products	200	200	250	250	250
Other Uses (est.)	90	90	90	85	110
Net Exports	328	900	1,100	1,300	1,550
Total Fiber Recovery	13,550	15,150	19,050	23,850	29,000
Recovered via Energy/Fuel Options	Neg.	650	2,000	7,250	15,350
Total Recovery	13,550	15,800	21,050	31,100	44,350
Net Paper Waste Disposal	41,500	41,150	47,900	48,850	49,300
Percent Recovery of Demand	21.0	23.8	26.5	33.2	40.6
Percent Recovery of Waste Paper Generated	24.6	27.7	30.5	38.9	47.4
Percent Disposal of Paper Waste Generated	75.4	72.3	69.5	61.1	52.6

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a/ Includes that recovered within solid waste management systems by source and mechanical separation.

Source: Midwest Research Institute.

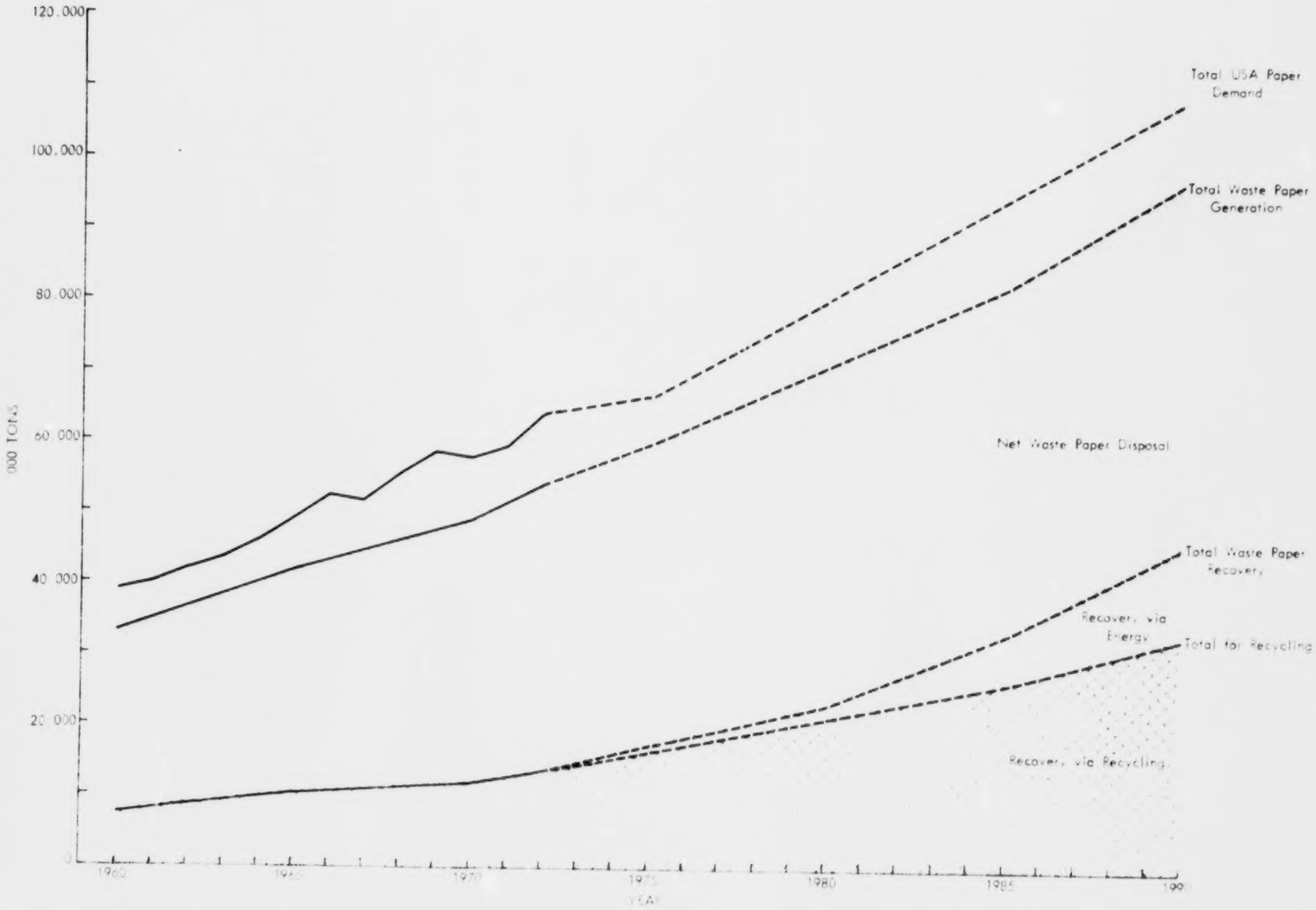

Figure 28 - Summary of Resource Recovery Forecasts for Paper, 1972-1990

The actual disposal of waste paper via landfill and incineration will rise from 41.5 million tons in 1972 to 49.3 million tons in 1990. However, by 1980 the quantities of waste paper going into disposal systems (as opposed to recovery systems) will have nearly leveled out in spite of a continued increase in demand for paper products. Thus the effect of paper recovery techniques on the nation's waste stream will be significant, in the absence of direct legislative intervention at the federal level, even though the true potential of recovery would be significantly higher.

Forecasts of Paper Demand

The consumption* or demand** for paper has been reasonably predictable over a long period of time. Of course, the fortunes of selected grades of paper have prospered and waned as specific end uses and intermaterials competition have changed the demand patterns. Nonetheless, the nation's use of paper has grown (and declined) in concert with the growth (and decline) of real GNP.

There are literally thousands of paper products made, but they can be classified generally into a few broad categories: communications, packaging, personal products, industrial products and other. The communication papers encompass most paper grades--newsprint, printing paper, "book" paper and "fine" paper. Most packaging grades are paperboard: linerboard, corrugating medium, folding boxboard, but also include wrapping and sack paper.

Personal products come mainly in the form of tissue--towels, napkins, toilet paper and the like. Industrial products include panelboard for furniture and autos, roofing felts, construction paper (gypsum liner), hard pressed board; tube, can and drum and others.

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* Usually defined as: production + imports - exports.

** Demand is used as a synonym to consumption. It is assumed that demand will be equaled by supply and that there is no gap between demand and actual consumption.

MRI has detailed the market aspects of paper demand in several previous studies.* These detailed data are not discussed or "reinvented" here, but are presented as the basic data required in this study.

The forecast of demand is the key statistic around which the related materials factors revolve. The demand (or consumption) sets the requirements for raw materials which in turn determines to what extent virgin and recycled paper may be used.

Each paper grade follows its own demand pattern and MRI's forecasts are based on the demand for the various grades of paper. In turn, that demand pattern is set by requirements for the finished products that the paper is converted to--corrugated boxes, newspapers and the like.

Also "consumption" leads to the inevitable discard of the product as waste. The nature of the product and its end use largely determine where it will be discarded, in what form and how. For example, corrugated boxes are discarded where the contents are emptied, usually a retail store, warehouse, or industrial plant. By contrast, toilet paper "disappears" from the municipal waste stream because it is discarded into sewer systems.

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* The previous studies by Midwest Research Institute that are used as substantive background for this chapter are:

"Paper Recycling--The Art of the Possible 1970-1985," The Solid Waste Council of the Paper Industry, March 1973, American Paper Institute, Inc., XX, 181 pp.

"Salvage Markets for Materials in Solid Waste," U.S. Environmental Protection Agency, No. SW-29C, U.S. Government Printing Office, Washington, D.C., 1972, XXI, 187 pp.

"The Role of Nonpackaging Paper in Solid Waste Management, 1966 to 1976," Public Health Service Publication No. 2040, Washington, U.S. Government Printing Office, 1971, X, 76 pp.

"The Role of Packaging in Solid Waste Management, 1966 to 1976," Public Health Service Publication No. 1855, U.S. Government Printing Office, 1971, X, 205 pp.

Thus, the forecasts of demand set the stage for determining how much of what kinds of paper products end up as waste paper and where. In turn, these data can be used to determine how much of what kinds of waste paper are recoverable and where it might be used for recycling or other recovery practices such as combustion of paper in mixed waste to recover the heat content.

The grade-by-grade forecasts and total demand forecasts were developed on the basis of several data sources. MRI relied heavily on industrial sources for general trends as well as specific grade categories. In addition, industry associations were also consulted. Much of the forecast was developed to 1985 in a previous study.* However, a significant effort was made to update the demand forecasts, and to reflect the long-term effects of the 1973 "boom" in demand and subsequent 1974 decline as economic recession came to the economy. The forecasts were developed independently and cannot be attributed to specific outside sources.

Forecast Results

The total demand for paper in the United States has paralleled real GNP quite closely in the past, and this general correlation will be valid for some years to come. However, the paper industry is a mature industry and the rate of growth of paper demand will be declining in the 1975 to 1990 period. Many competitive material displacements that took place in the 1960's are now nearly complete (e.g., paper for wood) while plastics and metals continue to make some inroads in packaging and other products. Some end uses for paper have reached their growth limits (e.g., setup boxes); new uses for paper will stimulate further growth in selected grade groups, e.g., printing and fine paper for expanding communications uses, and containerboard for packaging applications.

The paper industry's production will increase at an annual rate of 2.9 percent from 1973 to 1990; consumption will also increase at an annual rate of 2.9 percent (Table 91). Total industry production will increase from 59.3 million tons in 1972 to 102.8 million tons in 1990. At the same time, paper and paperboard consumption in the U.S. will grow from 64.4 million tons to 109.2 million tons, an increase of 70 percent over the 18-year period.

The forecasts were built up on a grade-by-grade basis. However, the forecast growth rates for the period 1973 to 1990 appear to be low compared to the base period of 1963 to 1973. There are several reasons for this. First, the year 1973 was a boom year in the industry and this introduces

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* "Paper Recycling-the Art of the Possible 1970-1985," op.cit.

TABLE [illegible]

PAPER DEMAND AND PRODUCTION IN THE U.S., 1963 - 1990
(In thousand tons)

Grade and Category	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1975	1980	1985	1990	Growth Rate (1963-1975)	Growth Rate (1975-1990)
Paper																	
Newsprint Production	2,213	2,249	2,180	2,347	2,599	2,956	3,252	3,345	3,321	3,451	3,413	3,200	3,900	4,700	5,300	4.5	3.0
Net Imports	5,295	5,837	6,238	6,892	6,509	6,333	6,663	6,491	6,715	6,955	7,313	7,230	8,000	8,600	9,600	3.2	1.5
Total Demand	7,508	8,086	8,418	9,239	9,108	9,289	9,915	9,836	10,036	10,406	10,726	10,430	11,900	13,300	14,900	3.6	2.1
Groundwood Printing	974	1,055	1,134	1,287	1,306	1,316	1,405	1,462	1,337	1,439	1,560	1,570	1,820	2,080	2,350	4.8	2.6
Coated Book Paper	2,374	2,584	2,778	3,052	3,040	3,077	3,279	3,203	3,179	3,420	3,766	3,835	4,660	5,670	6,720	4.7	3.8
Uncoated Book Paper	1,897	1,962	2,111	2,370	2,316	2,614	2,691	2,707	2,873	3,098	3,185	3,300	4,010	4,760	5,640	5.3	3.4
Writing Papers	1,928	2,047	2,261	2,512	2,477	2,680	2,920	2,861	2,903	3,246	3,689	3,810	4,640	5,650	6,700	6.8	3.6
Bristols	753	780	871	924	982	1,009	1,047	998	977	1,062	1,134	1,105	1,340	1,590	1,840	4.2	3.0
Packaging and Ind. Conv. (unbl.)	3,158	3,239	3,316	3,417	3,371	3,629	3,712	3,696	3,711	3,908	4,025	4,110	4,650	5,260	5,950	2.5	2.3
Other Packaging and Ind. Conv.	1,063	1,080	1,142	1,145	1,175	1,233	1,287	1,267	1,263	1,322	1,319	1,315	1,470	1,640	1,830	2.2	2.1
Special Industrial Paper	242	284	306	337	332	370	389	371	388	441	478	500	640	780	930	6.2	4.0
Tissue	2,563	2,721	2,862	3,082	3,195	3,376	3,550	3,748	3,863	4,005	3,933	3,960	4,590	5,270	5,960	4.4	2.5
Total Demand[a]	22,418	23,759	25,160	27,314	27,257	28,532	30,161	30,053	30,478	32,343	33,748	33,935	39,773	45,000	52,800	4.1	2.7
Paperboard																	
Linerboard--total	6,414	6,908	7,481	8,347	8,215	9,044	9,692	9,403	9,531	10,856	11,356	11,145	14,100	17,600	21,900	5.8	4.0
Recycled	677	693	750	767	498	407	347	270	282	279	289	355	920	1,760	2,200	8.9	13.0
Solid Wood Pulp	5,737	6,215	6,731	7,580	7,718	8,636	9,345	9,133	9,249	10,578	11,067	10,790	13,180	15,840	19,700	6.8	3.5
Corrugating Medium--total	2,962	3,165	3,438	3,800	3,743	4,062	4,395	4,264	4,520	4,846	5,255	5,130	6,500	8,100	10,080	5.8	3.9
Recycled	675	718	800	890	761	691	778	859	960	972	1,128	1,120	1,750	2,600	3,330	5.3	6.6
Solid Wood Pulp	2,287	2,447	2,638	2,910	2,982	3,371	3,617	3,405	3,580	3,874	4,127	4,010	4,750	5,500	6,750	6.1	2.9
Container Chipboard (recycled)	263	269	280	313	290	283	309	297	303	316	317	275	350	400	450	2.3	2.1
Other Containerboard	1,827	2,191	2,336	2,451	2,511	3,001	3,437	3,245	3,664	3,892	3,678	3,575	4,650	5,800	6,800	7.5	3.7
Recycled	907	929	935	920	908	1,066	1,163	1,074	1,238	1,348	1,386	1,328	1,750	2,200	2,680	4.3	3.9
Solid Wood Pulp	920	1,262	1,401	1,531	1,603	1,935	2,274	2,171	2,426	2,544	2,292	2,247	2,900	3,600	4,120	9.5	3.5
Total Containerboard	11,465	12,533	13,535	14,910	14,760	16,389	17,833	17,309	18,017	19,911	20,606	20,120	25,600	31,900	39,230	6.0	3.8
Recycled	2,507	2,595	2,748	2,866	2,436	2,447	2,561	2,474	2,732	2,893	3,110	3,070	4,770	6,960	8,660	2.2	6.2
Solid Wood Pulp	8,958	9,938	10,787	12,044	12,324	13,962	15,262	14,835	15,285	17,018	17,496	17,050	20,830	24,940	30,570	6.9	3.2
Folding Boxboard--total	3,636	3,752	3,889	4,060	4,021	4,218	4,262	4,080	4,139	4,440	4,705	4,450	4,950	5,700	6,070	2.6	1.5
Recycled	2,562	2,594	2,659	2,752	2,660	2,730	2,629	2,473	2,408	2,477	2,521	2,308	2,330	2,680	2,740	0.0	0.5
Solid Wood Pulp	1,074	1,158	1,231	1,308	1,361	1,488	1,633	1,607	1,731	1,963	2,184	2,142	2,620	3,020	3,330	7.4	2.5
Setup Boxboard--recycled	527	534	547	560	496	520	499	467	448	455	465	400	440	440	440	0.0	0.0
Milk Carton and Food Service--solid	1,255	1,295	1,384	1,476	1,456	1,596	1,665	1,693	1,646	1,636	1,595	1,570	1,760	1,960	2,160	2.4	1.8
Other Boxboard--total	1,711	1,840	1,985	2,192	2,087	2,181	2,118	1,835	1,786	2,040	2,201	2,130	2,350	2,600	2,850	2.3	1.9
Recycled	1,312	1,403	1,494	1,617	1,558	1,617	1,584	1,523	1,526	1,680	1,787	1,700	1,830	1,980	2,130	3.1	1.5
Solid Wood Pulp	399	437	491	575	529	564	534	312	260	360	414	430	520	620	720	0.4	3.4
Total Boxboard	7,128	7,421	7,796	8,288	8,060	8,515	8,543	8,074	8,020	8,571	8,966	8,550	9,500	10,700	11,520	[illegible]	[illegible]
Recycled	4,493	4,612	4,784	4,987	4,781	4,916	4,751	4,506	[illegible]	[illegible]	[illegible]	4,400	4,600	4,900	5,310	0.8	[illegible]
Solid Wood Pulp	2,635	2,809	3,012	3,281	3,279	3,599	3,792	3,568	3,596	3,946	4,191	4,150	4,900	5,600	6,210	4.6	2.2
Total Paperboard	18,594	19,954	21,332	23,179	22,819	24,904	26,376	25,383	26,037	28,503	29,572	28,670	35,100	42,400	50,750	4.6	3.8
Exports (unbl. kraft 90%)	829	1,098	1,178	1,295	1,470	1,957	2,084	2,163	2,443	2,370	2,245	2,200	2,680	3,250	3,960	10.4	[illegible]
Total Domestic Demand	17,765	18,856	20,154	21,884	21,349	22,947	24,292	23,220	23,594	26,133	27,327	26,470	32,420	39,150	46,790	4.4	[illegible]
Wet Machine Board	139	133	150	149	147	162	153	144	140	146	134	135	140	145	150	0.0	0.7
Construction Paper	1,448	1,527	1,567	1,486	1,498	1,564	1,592	1,390	1,862	1,954	1,840	1,800	2,030	2,270	2,330	2.4	2.0
Insulating and Hard Pressed Board	2,255	2,454	2,555	2,396	2,407	2,831	3,000	2,828	3,366	3,780	4,073	4,150	5,050	6,000	6,950	6.1	3.7
Total Other	3,842	4,114	4,272	4,031	4,052	4,557	4,745	4,362	5,368	5,880	6,047	6,385	7,220	8,415	9,630	4.8	2.8
Grand Total--All Grades	44,175	46,719	49,566	53,329	53,658	56,036	59,198	57,834	59,446	64,336	67,171	66,490	79,360	93,565	104,240	4.1	2.8

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a/ Does not add to column totals because data source does not make import-export adjustments each by grade.

Note: Paperboard grades are adjusted for exports but not imports. This has the effect of showing slightly higher consumption than actual, but only about [illegible] tons per year. API production data for paperboard does not catch surplus of census data. However, [illegible] has been comparable [illegible] on total production within [illegible] percent.

Sources: "Statistics of Paper and Paperboard, [illegible]," American Paper Institute, [illegible] data for [illegible]; Midwest Research Institute (future data).

a "peak" into a key year for growth into calculations for the base periods. This has the effect of showing a "high" growth rate for the period preceding 1973 and a "low" growth rate for the period 1973 to 1990. Second, we have shown declining production for 1974 and 1975 before resumption of "normal" growth rates, to reflect an economic slowdown. Third, we have shown a declining rate of growth for most grades of paper beyond 1980. The forecasts in terms of tonnage are consistent with long-term trends and the outlook for paper demand on a grade-by-grade basis.

In the paper category, the highest growth rates forecast are for books, writing, bristols and special industrial papers (3.0 to 4.0 percent per year) while the lowest rates are in groundwood printing paper, newsprint, packaging and tissue at 2.1 per count to 2.4 percent per year. In paperboard, the most impressive gains will be made in the containerboard uses--3.8 percent per year, while many types of paperboard that traditionally use high waste paper content will decline or grow only at a low rate--setup boxboard, gypsum liner, folding boxboard, and tube, can, and drum paper-board. However, the recycled types of containerboard (linerboard and corrugating medium will grow at rates well in excess of other recycled grades and of the virgin fiber types as recycling establishes something of a unique growth pattern in these grades (Table 91). The use of hard-pressed board will grow significantly--3.2 percent per year--as new end uses open up in building products and related uses.

With this wide range in demand patterns, the makeup of the grade categories will lead to changes in the availability of some important end use products. This means that raw materials options and waste utilization options will change somewhat in the future. For example, containerboard (domestic use) will be 29.7 percent of total consumption in 1990, compared to 24.9 percent in 1972. Result: relatively more demand for unbleached fiber for use in corrugated containers and increased availability of containers that are discarded. Thus, while absolute tonnage will increase in all categories, the makeup of the grade profile will change, too. In turn, the composition of the paper component of the waste stream will also change over time.

It should be obvious from the forecasts that those products that constitute the greatest percentage of demand also create the greatest amount of solid waste and also the greatest opportunity for recovery for recycling.

The demand profile given dictates in what grades the paper industry must increase its producing capacity, since 1972 and 1973 saw the industry running nearly "flat out" with little new capacity scheduled for completion in the next 2 years. The raw materials options are thus "open" in the sense that both virgin and recycled fibers can be chosen to increase the industry's output in the near future. Probably only in World War II did such a comparable condition previously exist in the paper industry. And, as has been shown in the summary data for this chapter, the recovery of waste paper for recycling purposes will likely increase rapidly in the future, more rapidly than total demand for paper products will increase.

Total paper demand (consumption) is related to real GNP and population growth. Working from published forecasts of population and real GNP (in 1958 prices), we related total paper demand to these basic growth indicators (Table 92). Total paper demand will increase from 617 pounds per capita in 1972 to 840 pounds per capita in 1990, an increase of 36 percent in 18 years; this compares to about a 60 percent increase in the 18 years prior to 1972 (Table 92, Figure 31). Likewise, related to GNP, paper demand will decline from 81,400 tons per billion dollars real GNP in 1972 to 75,300 tons per billion dollars real GNP in 1990. This relationship has ranged from 76,000 to 81,000 tons (seldom above) since 1947. The decline forecast reflects the fact that service sectors of the economy will grow more important relative to manufactured products in the next 2 decades. The same data are also given for the paper and paperboard sectors of paper demand (Table 92).

Waste Paper Generation

Relating Waste Paper Generation to Total Demand: Our orientation in this study was to characterize the mixed municipal waste stream. Thus, we have viewed waste paper from that perspective and constructed a profile of waste paper generation on the basis of its impact on municipal solid waste. Of course, the quantity of paper generated as waste relates directly to total consumption of paper.

By their nature, paper products are not designed for permanence--they are designed to do a job and to be discarded or recycled through the manufacturing process. In practice, some paper products do have a permanence and long-term value--books, filing records, construction products and the like.

For the most part, however, waste paper is created as rapidly as it is produced, purchased and used as a product. In some cases, the life of the paper product is probably much shorter than the time it took to deliver it to the customer. The newspaper is a classic example. Usually there is a several months lag between the time that a pulpwood tree is harvested and the daily newspaper imprints it and sells it. The reader discards the paper within minutes and the "value" in the product (to nearly every reader) lasts no more than 24 hours because it is replaced by yet another edition. Instant waste! It is then either collected for recycling

TABLE 92

PAPER CONSUMPTION RELATIONSHIPS TO POPULATION AND GROSS NATIONAL PRODUCT

(Pounds per capita and thousand tons per $ billion GNP)

		Gross Nat'l. Product In 1958 Prices (Real GNP)	All Grades Total Consumption			Paper Total Consumption			Paperboard Total Consumption			Construction Paper and Paperboard Total Consumption		
Year	Population (000)	($ Billion)	Tons (000)	Lbs/Capita	000 Tons Per $ Billion Real GNP	Tons (000)	Lbs/Capita	000 Tons Per $ Billion Real GNP	Tons (000)	Lbs/Capita	000 Tons Per $ Billion Real GNP	Tons (000)	Lbs/Capita	000 Tons Per $ Billion Real GNP
1947	144,126	309.9	24,749	343.4	79.9	13,167	182.7	42.5	9,100	126.3	29.4	2,333	32.4	7.5
1948	146,631	323.7	26,083	355.9	80.6	14,062	191.8	43.4	9,299	126.8	28.7	2,579	35.2	8.0
1949	149,188	324.1	26,695	331.0	76.2	13,645	182.9	42.1	8,942	119.9	27.6	1,979	26.5	6.1
1950	152,271	355.3	29,012	381.1	81.7	15,333	202.2	43.2	10,868	143.3	30.6	2,647	34.9	7.5
1951	154,878	383.4	30,561	394.6	79.7	16,310	211.3	42.5	11,449	148.3	29.9	2,652	34.4	6.9
1952	157,553	395.1	29,017	368.3	78.4	15,620	198.9	30.5	10,654	135.7	27.0	2,604	33.2	6.6
1953	160,184	412.8	31,360	391.6	76.0	16,232	203.4	39.3	12,229	153.2	29.6	2,744	34.4	6.7
1954	163,026	407.0	31,379	385.0	77.1	16,360	201.5	40.2	11,970	147.4	29.4	2,914	35.9	7.2
1955	165,931	438.0	34,619	418.5	79.3	17,698	214.1	40.4	13,582	164.4	31.0	3,260	39.4	7.4
1956	168,903	446.1	36,496	432.2	81.8	19,306	229.5	43.4	13,928	165.7	31.2	3,116	37.1	7.0
1957	171,984	452.5	35,268	410.1	77.9	18,475	215.8	40.8	13,728	160.4	30.3	2,928	34.2	6.5
1958	174,882	447.3	35,119	401.6	78.5	18,103	208.0	40.5	13,790	158.5	30.8	3.104	35.7	6.9
1959	177,830	475.9	38,725	435.5	81.4	20,118	226.3	42.3	15,021	168.9	31.6	3,439	38.7	7.2
1960	180,667	487.7	39,138	433.3	80.3	20,546	227.4	42.1	15,150	167.7	31.1	3,266	36.2	6.7
1961	183,672	497.2	40,312	439.0	81.1	20,955	228.2	42.2	15,892	173.0	32.0	3,310	36.0	6.7
1962	186,504	529.8	42,216	452.7	79.7	21,770	233.5	41.1	16,816	180.3	31.7	3,485	37.4	6.6
1963	189,197	551.0	43,715	462.1	79.3	22,418	237.0	40.7	17,455	184.5	31.7	3,702	39.1	6.7
1964	191,833	481.1	46,384	483.6	79.8	23,729	247.4	40.8	18,522	193.1	31.9	3,980	41.5	6.9
1965	194,237	617.8	49,102	505.6	79.5	25,160	259.1	40.7	19,670	202.5	31.8	4,122	42.4	6.7
1966	196,485	658.1	52,680	536.2	80.0	27,314	278.0	41.5	21,336	217.2	32.4	3,881	39.5	5.9
1967	198,629	675.2	51,945	522.8	76.9	27,257	274.4	40.1	20,635	207.8	30.6	3,905	39.3	5.8
1968	200,619	706.6	55,664	554.9	78.8	28,532	284.4	40.4	22,575	225.0	32.0	4,396	43.8	6.2
1969	202,677	725.6	58,915	581.4	81.2	30,161	297.6	41.6	24,009	236.9	33.1	4,592	45.3	6.3
1970	204,879	722.5	57,940	565.6	80.2	30,054	293.4	41.6	23,325	227.7	32.3	4,418	43.1	6.1
1971	207,045	745.9	59,563	575.3	79.9	30,478	294.4	40.9	23,711	229.0	31.8	5,228	50.5	6.0
1972	208,842	790.7	64,385	616.6	81.4	32.343	309.7	40.9	26,163	250.6	33.0	5,734	43.9	7.2
1973	210,400	837.4	67,240	639.2	80.3	33,748	320.8	40.3	27,445	260.9	32.8	5,912	56.2	7.1
1975[a]	215,000	860.0	66,490	618.5	77.3	33,935	315.6	39.5	26,470	246.2	30.8	5,950	55.3	6.9
1980	230,000	1,040.0	79,360	690.1	76.3	39,720	258.4	38.2	32,420	281.9	31.2	7,220	62.8	6.9
1985	244,000	1,250.0	93,565	766.9	74.9	46,000	377.0	26.8	39,150	320.9	31.3	8,415	69.0	6.7
1990	260,000	1,450.0	109,240	840.3	75.3	52,800	406.2	36.4	46,790	360.0	32.3	9,650	74.2	6.7

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[a] Preliminary

Source: "Statistics of Paper and Paperboard 1974," American Paper Institute, 1974. Midwest Research Institute forecasts.

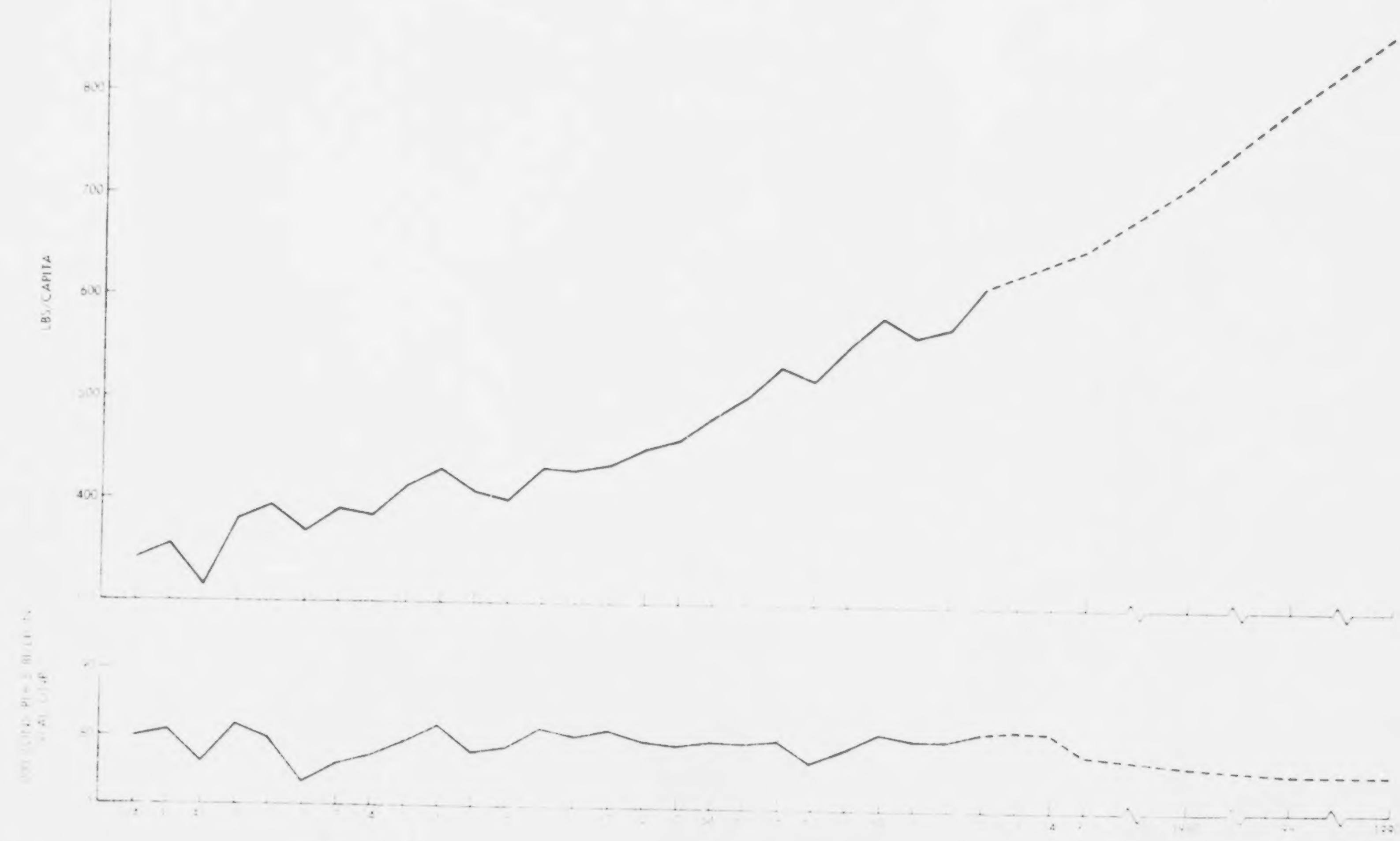

Figure 31 - Paper Consumption in Pounds per Capita
and 1,000 Tons per $ Billion of GNP

or disposed of in a solid waste management system (after some storage period by the consumer).

Consumption of paper products has increased dramatically as a consequence of economic activity and the convenience of one-time use product substitution ("disposables") for "reusable" products (e.g., paper towels instead of cloth towels). Markets for many paper products have developed along these lines:

1. Products that have a short useful life;
2. Products that have a single time use, and cannot be reused,
3. Products for which there is a continuous and growing need;
4. Products that are "convenient" to use because of their "disposable" or "throw away" characteristics; and
5. Products that incorporate more material per unit of use.

Thus, the growth areas of the 1960's were: tissue products, e.g., double-ply toilet tissue to displace single-ply; paper toweling to replace cloth napkins, etc.; paper cups, plates, etc.; communications papers (all types) and packaging papers, all of which meet some or all of the "market objectives" set out above. This is why economic growth translated into increased demand for paper products, and will continue to do so in the years ahead. Paper products are key elements in the nation's economy, and economic growth means increasing paper demand (i.e., tons).

This leads to solid waste generation in proportion to total consumption. In addition, from 1945 to 1973, a period of 27 years, the rate of recycling of paper declined. Consequently, proportionately more virgin fiber was utilized and proportionately less waste paper was withdrawn from the waste stream. Thus, there was in this 30-year period greater solid waste disposal than the total increase in consumption would have indicated.

Calculating Waste Paper Generation Rates

Not all paper that is manufactured and used ends up "instantly" in the municipal waste stream. For this reason, we calculated current waste paper generation as it relates to municipal solid waste. There are several factors that determine whether the paper product will enter the municipal waste stream essentially as produced and used by the purchaser. They are:

1. Lifetime of the product. A product "inventoried" or in use for more than 1 year will not affect the waste stream until later--books, business records, appliances, shoeboard, etc.

This affects the total waste generation in a given year when total consumption is growing. Thus, if a product has a lifetime of 5 years, then purchased in 1970 will be discarded in 1975. In the meantime, total consumption of that product will likely increase and it will appear in 1975 that we do not discard as much as we consume. It is the time delay and increased output that causes this (e.g., 1975's output will go into use while 1970's output will come into the waste stream). The time delay effects of product use were put into our calculations.

2. End use of the product that leads to discard into another media or waste stream. (This category we refer to as "diverted" from the waste stream.)

Not all paper products retain their original form or are discarded into the municipal waste stream. The principal examples are: toilet paper which enters sewage systems; cigarette paper which is burned in use and a number of products that lose their identity as paper and are not discarded to municipal waste in a conventional manner. Also included: gypsum wallboard and roofing felts (demolition waste), auto panelboard, funiture panels, shoe board and the like. We account for this category to realistically assess the potentially recoverable paper that remains in the municipal waste stream, in a form identifiable as paper. That is, paper incorporated into other products becomes identified with them rather then as a paper discard.

Given these two categories, we first determined what reduction of waste generation would occur in any given year as a ratio of total consumption for that year. These ratios were based partly on our own judgment and partly on the basis of related measures that could be applied. The methodology and derivation of most of these factors were detailed in a previous MRI study.[1] However, the basis of calculation for each grade is set out in Appendix E.

The calculation of gross municipal waste paper generation is given for selected years from 1965 to 1990 (Tables 93-99).[2] Of course, the starting point for each grade of paper is total demand. From that we initially deducted a converting scrap that might occur in that grade (based on known or estimated scrap rates, e.g., newsprint was about 3 percent based on scrap generation rates reported to the American Newspapers Publishers Association. This resulted in "net" consumption, i.e., that part going out as finished product.

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[1] "The Role of Nonpackaging Paper in Solid Waste Management, 1966-1976," op. cit. See pages 51-63. Also see Appendix E for details.

[2] Table 95 gives a complete detail of all calculations for 1972 while the other tables in this source were developed on the same basis, but the calculation detail was omitted.

TABLE 93

PROFILE OF MUNICIPAL SOLID WASTE GENERATION OF PAPER, 1965

(In thousand tons)

Paper Grade Category	Total Demand	Less Converting Scrap	Net Demand	Diverted or Delayed Entry To Solid Waste	Entering Municipal Waste	Gross Waste Discard
Newsprint	8,400	350	8,050	100	7,950	8,300
Printing Paper	6,000	600	5,300	600	4,700	5,400
Fine Paper	3,150	250	2,900	400	2,500	2,750
Ind. Conv. Pkg.	4,750	250	4,500	100	4,400	4,650
Tissue	2,850	150	2,700	1,050	1,650	1,800
Total Paper	25,150	1,600	23,450	2,250	21,200	22,900
Containerboard	11,200	1,250	9,950	200	9,750	11,000
Other Containerboard	1,350	100	1,250	600	650	750
Folding Boxboard	3,900	700	3,200	50	3,150	3,850
Set-up Boxboard	550	50	500	--	500	550
Milk and Food Service	1,400	150	1,250	--	1,250	1,400
Other Folding Boxboard	1,750	200	1,550	250	1,300	1,500
Total Paperboard	20,150	2,450	17,700	1,100	16,600	19,050
Wet Machine and Construction Paper	1,700	150	1,550	1,400	150	300
Insulating and Hard Pressed Board	2,550	200	2,350	2,100	250	450
Total Construction	4,250	350	3,900	3,500	400	750
Grand Totals	49,550	4,500	45,050	6,850	38,200	42,700
Ratio to Total Demand	1.000	0.091	0.909	0.138	0.771	0.862

Note: Values were rounded to the nearest 50,000 tons in these calculations.

Source: Midwest Research Institute.

TABLE 94

PROFILE OF MUNICIPAL SOLID WASTE GENERATION OF PAPER, 1970

(In thousand tons)

Paper Grade Category	Total Demand	Less Converting Scrap	Net Demand	Diverted or Delayed Entry To Solid Waste	Entering Municipal Waste	Gross Waste Discard
Newsprint	9,850	400	9,450	100	9,350	9,750
Printing Paper	7,350	900	6,450	700	5,750	6,650
Fine Paper	3,850	600	3,250	400	2,850	3,450
Ind. Conv. Pkg.	5,300	250	5,050	100	4,950	5,200
Tissue	3,750	200	3,550	1,350	2,200	2,400
Total Paper	30,100	2,350	27,750	2,650	25,100	27,450
Containerboard	13,950	1,550	12,400	250	12,150	13,700
Other Containerboard	1,550	100	1,450	700	750	850
Folding Boxboard	4,100	1,050	3,050	50	3,000	4,050
Set-up Boxboard	450	50	400	0	400	450
Milk and Food Service	1,700	200	1,500	0	1,500	1,700
Other Folding Boxboard	1,500	150	1,350	200	1,150	1,300
Total Paperboard	23,250	3,100	20,150	1,200	18,950	22,050
Wet Machine and Construction Paper	1,700	150	1,550	1,400	150	300
Insulating and Hard Pressed Board	2,850	200	2,650	2,400	250	450
Total Construction	4,550	350	4,200	3,800	400	750
Grand Totals	57,900	5,800	52,100	7,650	44,450	50,250
Ratio to Total Demand	1.000	0.100	0.900	0.132	0.768	0.888

Note: Values were rounded to the nearest 50,000 tons in these calculations.

Source: Midwest Research Institute.

TABLE 95

PROFILE OF MUNICIPAL SOLID WASTE GENERATION OF PAPER, 1972
(In thousand tons)

Paper Grade Category	Total Demand	Less Converting Scrap	Net Demand	Diverted or Delayed Entry To Solid Waste	Entering Municipal Waste	Gross Waste Discard	Ratio For Diverted/Delayed	Ratio For Entry To Municipal Waste	Scrap Ratio To Demand
Newsprint	10,400	400	10,000	100	9,900	10,300	0.01	0.99	0.04
Printing Paper	8,000	950	7,050	800	6,250	7,200	0.11	0.89	0.12
Fine Paper	4,300	350	3,950	500	3,450	3,800	0.13	0.87	0.08
Ind. Conv. Pkg.	5,700	300	5,400	100	5,300	5,600	0.02	0.98	0.05
Tissue	4,000	200	3,800	1,450	2,350	2,550	0.38	0.62	0.05
Total Paper	32,400	2,200	30,200	2,950	27,250	29,450	--	--	--
Containerboard	16,000	1,750	14,250	300	13,950	15,700	0.02	0.98	0.11
Other Containerboard	2,000	150	1,850	950	900	1,050	0.50	0.50	0.07
Folding Boxboard	4,450	800	3,650	50	3,600	4,400	0.02	0.98	0.18
Set-up Boxboard	450	50	400	--	400	450	0.02	0.98	0.10
Milk and Food Service	1,650	200	1,450	--	1,450	1,650	0.01	0.99	0.12
Other Folding Boxboard	1,550	150	1,400	200	1,200	1,350	0.15	0.85	0.10
Total Paperboard	26,100	3,100	23,000	1,500	21,500	24,600	--	--	--
Wet Machine and Construction Paper	2,100	150	1,950	1,750	200	350	0.90	0.10	0.08
Insulating and Hard Pressed Board	3,800	300	3,500	3,150	350	650	0.90	0.10	0.08
Total Construction	5,900	450	5,450	4,900	550	1,000	--	--	--
Grand Totals	64,400	5,750	58,650	9,350	49,300	55,050	0.16[a/] 0.145[b/]	0.84[a/] 0.855[b/]	-- 0.089[b/]
Ratio to total demand	1,000	0.089	0.911	0.145	0.765	0.855			

[a/] Calculated from inidivdual grade totals to net demand.

[b/] Calculated as the ratio to total demand.

Note: Values were rounded to the nearest 50,000 tons in these calculations.

Source: Midwest Research Institute.

TABLE 96

PROFILE OF MUNICIPAL SOLID WASTE GENERATION OF PAPER, 1975

(In thousand tons)

Paper Grade Category	Total Demand	Less Converting Scrap	Net Demand	Diverted or Delayed Entry To Solid Waste	Entering Municipal Waste	Cross Waste Discard
Newsprint	10,550	400	10,150	100	10,450	10,450
Printing Paper	8,700	1,050	7,650	850	6,800	7,850
Fine Paper	4,900	400	4,500	600	3,900	4,300
Ind. Conv. Pkg.	5,950	300	5,650	100	5,550	5,850
Tissue	3,950	200	3,750	1,450	2,300	2,500
Total Paper	34,050	2,350	31,700	3,100	29,000	30,950
Containerboard	16,550	1,800	14,750	300	14,450	16,250
Other Containerboard	1,800	150	1,650	800	850	1,000
Folding Boxboard	4,450	800	3,650	50	3,600	4,400
Set-up Boxboard	400	50	350	--	350	400
Milk and Food Service	1,550	200	1,350	150	1,200	1,400
Other Folding Boxboard	1,700	150	1,550	250	1,300	1,450
Total Paperboard	26,450	3,150	23,300	1,550	21,750	24,900
Wet Machine and Construction Paper	1,950	150	1,800	1,600	200	350
Insulating and Hard Pressed Board	4,150	350	3,800	3,400	400	750
Total Construction	6,100	500	5,600	5,000	600	1,100
Grand Totals	66,600	6,000	60,600	9,650	50,950	56,950
Ratio to Total Demand	1.000	0.090	0.910	0.145	0.765	0.855

Note: Values were rounded to the nearest 50,000 tons in these calculations.

Source: Midwest Research Institute.

TABLE 97

PROFILE OF MUNICIPAL SOLID WASTE GENERATION OF PAPER, 1980

(In thousand tons)

Paper Grade Category	Total Demand	Less Converting Scrap	Net Demand	Diverted or Delayed Entry To Solid Waste	Entering Municipal Waste	Gross Waste Discard
Newsprint	11,900	500	11,400	100	11,300	11,800
Printing Paper	10,500	1,250	9,250	1,000	8,250	9,500
Fine Paper	6,000	500	5,500	700	4,800	5,300
Ind. Conv. Pkg.	6,850	350	6,400	150	6,250	6,600
Tissue	4,600	250	4,350	1,650	2,700	2,950
Total Paper	39,850	2,850	36,900	3,600	33,300	36,150
Containerboard	20,950	2,300	18,650	400	18,250	20,550
Other Containerboard	2,400	200	2,200	100	2,100	2,300
Folding Boxboard	4,950	900	4,050	100	3,950	4,850
Set-up Boxboard	450	50	400	0	400	450
Milk and Food Service	1,750	200	1,550	0	1,550	1,750
Other Folding Boxboard	1,900	200	1,700	250	1,450	1,650
Total Paperboard	32,400	3,850	28,550	850	27,700	31,550
Wet Machine and Construction Paper	2,150	200	1,950	1,750	200	400
Insulating and Hard Pressed Board	5,050	400	4,650	4,200	450	850
Total Construction	7,200	600	6,600	5,950	650	1,250
Grand Totals	79,350	7,300	72,050	10,400	61,650	68,950
Ratio to Total Demand	1.000	0.092	0.908	0.131	0.777	0.869

Note: Values were rounded to the nearest 50,000 tons in these calculations.
Source: Midwest Research Institute.

TABLE 98

PROFILE OF MUNICIPAL SOLID WASTE GENERATION OF PAPER, 1985
(In thousand tons)

Paper Grade Category	Total Demand	Less Converting Scrap	Net Demand	Diverted or Delayed Entry To Solid Waste	Entering Municipal Waste	Gross Waste Discard
Newsprint	13,300	550	12,750	150	12,600	13,150
Printing Paper	12,500	1,500	11,000	1,200	9,800	11,300
Fine Paper	7,250	600	6,650	900	5,750	6,350
Ind. Conv. Pkg.	7,700	400	7,300	150	7,150	7,550
Tissue	5,250	250	5,000	1,900	3,100	3,350
Total Paper	46,000	3,300	42,700	4,300	38,400	41,700
Containerboard	26,100	2,850	23,250	500	22,750	25,600
Other Containerboard	3,050	200	2,850	1,450	1,400	1,600
Folding Boxboard	5,500	1,000	4,500	100	4,400	5,400
Set-up Boxboard	450	50	400	0	400	450
Milk and Food Service	1,950	250	1,700	0	1,700	1,950
Other Folding Boxboard	2,100	200	1,900	300	1,600	1,800
Total Paperboard	39,150	4,550	34,600	2,350	32,250	36,800
Wet Machine and Construction Paper	2,400	200	2,200	2,000	200	400
Insulating and Hard Pressed Board	6,000	500	5,500	4,950	550	1,050
Total Construction	8,400	700	7,700	6,950	750	1,450
Grand Totals	93,550	8,550	85,000	13,600	71,400	79,950
Ratio to Total Demand	1.000	0.091	0.908	0.145	0.763	0.854

Note: Values were rounded to the nearest 50,000 tons in these calculations.
Source: Midwest Research Institute.

TABLE 99

PROFILE OF MUNICIPAL SOLID WASTE GENERATION OF PAPER, 1990
(In thousand tons)

Paper Grade Category	Total Demand	Less Converting Scrap	Net Demand	Diverted or Delayed Entry To Solid Waste	Entering Municipal Waste	Gross Waste Discard
Newsprint	14,900	600	14,300	150	14,150	14,750
Printing Paper	14,700	1,750	12,950	1,450	11,500	13,250
Fine Paper	8,550	700	7,850	1,000	6,850	7,550
Ind. Conv. Pkg.	8,700	450	8,250	200	8,050	8,500
Tissue	5,950	300	5,650	2,150	3,500	3,800
Total Paper	52,800	3,800	49,000	4,950	44,050	47,850
Containerboard	32,450	3,600	28,850	600	28,250	31,850
Other Containerboard	3,500	250	3,250	1,650	1,600	1,850
Folding Boxboard	6,050	1,100	4,950	100	4,850	5,950
Set-up Boxboard	450	50	400	0	400	450
Milk and Food Service	2,150	250	1,900	0	1,900	2,150
Other Folding Boxboard	2,200	200	2,000	300	1,700	1,900
Total Paperboard	46,800	5,450	41,350	2,650	38,700	44,150
Wet Machine and Construction Paper	2,700	200	2,500	2,250	250	450
Insulating and Hard Pressed Board	6,950	550	6,400	5,750	650	1,200
Total Construction	9,650	750	8,900	8,000	900	1,650
Grand Totals	109,250	10,000	99,250	15,600	83,650	93,650
Ratio to Total Demand	1,000	0.092	0.908	0.143	0.770	0.860

Note: Values were rounded to the nearest 50,000 tons in these calculations.
Source: Midwest Research Institute.

For printing and writing paper, the amount diverted is about 12 percent, which is primarily a reflection of the fact that books and office records are retained for long periods and some may be retained nearly permanently. By contrast, newspapers and packaging papers have very low rates of delay in discard because they have little permanent value. Tissue is considered a high loss category because a large proportion is toilet tissue and is used and discarded outside municipal solid waste systems.

In paperboard, the packaging grades enter waste essentially as produced and used. The "other containerboard" category contains gypsum linerboard and industrial products such as panelboard. For this reason, about 50 percent of this category diverts from municipal waste. Similarly, the construction grades go into "permanent" structures for periods of 15 to 50 years after which they show up in special waste streams outside of "normal" municipal waste.

The total waste generation (including converting scrap) is about 85 percent of total consumption for 1972. By 1990, the percent entering municipal waste will have increased incrementally to about 86 percent of consumption. We emphasize that these values at this point are gross waste generation figures and have not yet been adjusted for waste paper removed from the waste stream for recycling or other uses. The calculation of net waste entering disposal systems follows in a later step.

Waste Paper Generated by Source

Once the gross generation of waste paper is calculated, it is possible to allocate waste generation by source, a procedure which is as much judgmental as it is based on good source data. Our approach was to allocate waste paper to residential and nonresidential (i.e., commercial/institutional and industrial) on the basis of end use.

In this case, the allocation of waste source was also based on previous MRI work and details developed for each grade in Appendix E.* The allocations were first made for the base year of 1972 and then to 1975 to 1990 on the basis of the same ratios developed for earlier years. The results are given in Tables 100 to 104 for the years 1972 to 1990. Once again, these calculations allocate gross waste generation including converting scrap and have not at this point made allowance for removal from the waste stream for recycling.

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* "Salvage Markets for Materials in Solid Waste," op.cit. (Chapter IV); and "The Components of Solid Waste," 14 pp. 1968, see pages 10-14. Proprietary study by Midwest Research Institute.

TABLE 100

WASTE PAPER GENERATED BY SOURCE, 1972

(In thousand tons)

Grade	Gross Waste Discarded	Household[a]	Nonhousehold	Converting Scrap
Newsprint	10,300	8,900	1,000	400
Printing Paper	7,200	3,750	2,500	950
Fine Paper	3,800	700	2,750	350
Industrial Coverting and Packaging	5,600	3,450	1,850	300
Tissue	2,550	1,650	700	200
Total Paper	29,450	18,450	8,800	2,200
Containerboard	15,700	1,000	12,950	1,750
Other Containerboard	1,050	450	450	150
Folding Boxboard	4,400	2,900	700	800
Setup Boxboard	450	350	50	50
Milk and Food Service	1,650	1,000	450	200
Other Boxboard	1,350	600	600	150
Total Paperboard	24,600	6,300	15,200	3,100
Construction	350	100	100	150
Insulating	650	150	200	300
Total Construction	1,000	250	300	450
Grand Total	55,050	25,000	24,300	5,750
Ratio to Total	1.000	0.454	0.441	0.105

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[a] Calculations for household and nonhousehold waste were based upon the discard patterns for each grade after adjustment for converting scrap from gross waste generated.

Source: Midwest Research Institute.

TABLE 101

WASTE PAPER GENERATED BY SOURCE, 1975
(In thousand tons)

Grade	Gross Waste Discarded	Household[a]	Nonhousehold	Converting Scrap
Newsprint	10,450	9,050	1,000	400
Printing Paper	7,850	4,100	2,700	1,050
Fine Paper	4,300	800	3,100	400
Industrial Converting and Packaging	5,850	3,600	1,950	300
Tissue	2,500	1,600	700	200
Total Paper	30,950	19,150	9,450	2,350
Containerboard	16,250	1,000	13,450	1,800
Other Containerboard	1,000	400	450	150
Folding Boxboard	4,400	2,900	700	800
Setup Boxboard	400	300	50	50
Milk and Food Service	1,400	850	350	200
Other Folding Boxboard	1,450	650	650	150
Total Paperboard	24,900	6,100	15,650	3,150
Construction	350	100	100	150
Insulating and Hard Pressed	750	150	250	350
Total Construction	1,100	250	350	500
Grand Total	56,950	25,500	25,450	6,000
Ratio to Total	1.000	0.448	0.447	0.105

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[a] Calculations were based upon the discard patterns for each grade after adjustment for converting scrap from gross waste generated.

Source: Midwest Research Institute.

TABLE 102

WASTE PAPER GENERATED BY SOURCE, 1980

(In thousand tons)

Grade	Gross Waste Discarded	Household[a]	Nonhousehold	Converting Scrap
Newsprint	11,800	10,200	1,100	500
Printing Paper	9,500	4,950	3,300	1,250
Fine Paper	5,300	950	3,850	500
Industrial Converting and Packaging	6,600	4,050	2,200	350
Tissue	2,950	1,900	800	250
Total Paper	36,150	22,050	11,250	2,850
Containerboard	20,550	1,300	16,950	2,300
Other Containerboard	2,300	1,050	1,050	200
Folding Boxboard	4,850	3,150	800	900
Setup Boxboard	450	350	50	50
Milk and Food Service	1,750	1,100	450	200
Other Folding Boxboard	1,650	700	750	200
Total Paperboard	31,550	7,650	20,050	3,850
Construction	400	100	100	200
Insulating and Hard Pressed	850	200	250	400
Total Construction	1,250	300	350	600
Grand Total	68,950	30,000	31,650	7,300
Ratio to Total	1.000	0.435	0.459	0.106

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[a] Calculations were based upon the discard patterns for each grade after adjustment for converting scrap from gross waste generated.

Source: Midwest Research Institute.

TABLE 103

WASTE PAPER GENERATED BY SOURCE, 1985

(In Thousand Tons)

Grade	Gross Waste Discarded	Household[a]	Nonhousehold[a]	Converting Scrap
Newsprint	13,150	11,350	1,250	550
Printing Paper	11,300	5,900	3,900	1,500
Fine Paper	6,350	1,150	4,600	600
Industrial Converting and Packaging	7,550	4,650	2,500	400
Tissue	3,350	2,150	950	250
Total Paper	41,700	25,200	13,200	3,300
Containerboard	25,600	1,600	21,150	2,850
Other Containerboard	1,600	700	700	200
Folding Boxboard	5,400	3,500	900	1,000
Setup Boxboard	450	350	50	50
Milk and Fold Service	1,950	1,200	500	250
Other Folding Boxboard	1,800	800	800	200
Total Paperboard	36,800	8,150	24,100	4,550
Construction	400	100	100	200
Insulating	1,050	200	350	500
Total Construction	1,450	300	450	700
Grand Total	79,950	33,650	37,750	8,550
Ratio to Total	1.000	0.421	0.472	0.107

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[a] Calculations were based upon the discard patterns for each grade after adjustment for converting scrap from gross waste generated.

Source: Midwest Research Institute.

TABLE 104

WASTE PAPER GENERATED BY SOURCE, 1990

(In thousand tons)

Grade	Gross Waste Discarded	Household[a]	Nonhousehold	Converting Scrap
Newsprint	14,750	12,750	1,400	600
Printing Paper	13,250	6,900	4,600	1,750
Fine Paper	7,550	1,350	5,500	700
Industrial Converting and Packaging	8,500	5,250	2,800	450
Tissue	3,800	2,450	1,050	300
Total Paper	47,850	28,700	15,350	3,800
Containerboard	31,850	2,000	26,250	3,600
Other Containerboard	1,850	800	800	250
Boxboard	5,950	3,900	950	1,100
Setup Boxboard	450	350	50	50
Milk and Food Service	2,150	1,350	550	250
Other Boxboard	1,900	850	850	200
Total Paperboard	44,150	9,250	29,450	5,450
Construction	450	100	150	200
Insulating and Hard Pressed	1,200	250	400	550
Total Construction	1,650	350	550	750
Grand Total	93,650	38,300	45,350	10,000
Ratio to Total	1.000	0.409	0.484	0.107

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[a] Calculations were based upon the discard patterns for each grade after adjustment for converting scrap from gross waste generated.

Source: Midwest Research Institute.

The allocation to the basic generation sources follows the product to its ultimate destination in use and finally in discard. Thus, newspapers largely going to individual homes (as opposed to commercial papers such as the Wall Street Journal) show up as household waste. Printing paper is used in offices and general business, but the bulk of printing paper tonnage goes into the home as books, magazines, direct mail advertising, and other printed material. By contrast, fine paper is largely a business paper category since it includes stationery, computer printout, forms and the like. Industrial converting and packaging is split almost evenly between homes (e.g., grocery sacks, wrapping paper) and business (bags, and "industrial" grades) paper. Tissue, as a personal use product, is consumed largely in the home as towels, napkins, toilet and facial tissue; in the business sector, it is used in the same manner except for small amounts of packaging tissue. Overall, about 45 percent of paper products showed up in households in 1972; 44 percent is in the nonhousehold sector; and 10 percent as converting scrap, created when rolls of paper are transformed into finished products.

In the paperboard group, the sources of waste generation reverse. Containerboard (i.e., corrugated containers) is a commercial product; we estimate only 6 percent gets into the home while 11 percent is converting scrap and 83 percent is discard in the nonhousehold sector. However, it is worthy of note that about one-third of the latter tonnage goes to industrial plants such as assembly plants (e.g., autos, appliances, TV, etc.) while the remaining two-thirds goes to wholesale and retail stores (e.g., supermarkets, drug and department stores). Boxboard is largely a packaging material that goes into the home containing consumer products (e.g., food). Likewise, milk and food service is predominately bleached paperboard used to package consumer food products, (e.g., milk, frozen food, etc.) The final grouping in paperboard is split between the two major generation sources. (Note that construction products have been previously shown in the "diverted" category.) The final ratios (for 1972) are 26 percent paperboard in the home, 62 percent in commercial/institutional (most of which is corrugated boxes) and 12 percent converting scrap.

The construction category affects both household and nonhousehold waste sources. In total, then, for 1972, the composite waste sources are: household, 45 percent; nonhousehold, 44 percent; and converting scrap 11 percent (Table 100 for 1972).

Each grade classification was extended on largely the same basis to 1990. The total gross waste paper generation increases from 55.0 million tons in 1972 to 93.7 million tons in 1990. The household sector will have declined to 41 percent in 1990; nonhousehold increasing to 48 percent and converting scrap remains at 11 percent (Table 104). This shift is largely the result of containerboard consumption increasing more rapidly than other grades. Details for intermediate years is given in Tables 101 to 104 for 1975, 1980, 1985 and 1990.

The distribution of gross waste paper generation by source is now estimated. The next step is to determine the recovery and recycling demand for waste paper and various grades as a preliminary to forecasting how and what removal from the waste stream will take place in the future.

Waste Paper Recycling in the Paper Industry

Historically, the paper industry has always been a large consumer of waste paper for raw materials and has increased its tonnage use of waste paper steadily to the point that in 1972 about 13 million tons were used for recycling in the paper industry. However, over the last 27 years the rate of recycling has declined--from 34.6 percent in 1945 to 20.1 percent in 1972.*

At the end of 1972, the paper industry stood poised on a "new" raw materials use threshold. The industry could follow history to lower rates of recycling for a few more years or a "turnaround" could occur in which recycled fiber began a comeback as a source of raw materials. Evidence could be compiled to support either outcome.**

In the early 1970's, conditions in the raw materials supply situation were changing rapidly. External forces were at work on the industry in the form of government, and public pressure and even customer pressure to "recycle." At the same time, the industry was entering the greatest raw materials and capacity squeeze it had experienced since World War II. Major companies that had never recycled significant quantities of waste paper were quietly installing incremental capacity to recycle old corrugated containers and old newspapers (both post-consumer waste goods). Other long-time recyclers were increasing output to meet booming paper demand. In the meantime, virgin fiber supplies were not so readily available, as weather, labor shortages and high prices combined to restrict growth in supply; most companies were operating at full pulp capacity too.

As the whole industry turned to waste paper to fill increasing demand, exports of waste paper also rose by more than 100 percent over 1972.

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* For the latter calculation American Paper Institute data were used. U.S. Bureau of Census data for 1972 would give a recycling rate of 17.5 percent but MRI considers the API as more comprehensive and complete data source today on waste paper recycling.

** See "Paper Recycling, the Art of the Possible, 1970 to 1985," op. cit.

A severe waste paper supply shortage developed and prices of waste paper doubled in a matter of months. Nonetheless, the industry had plans to use 1 million tons more waste paper in 1973 over 1972 (a good year) and exports added another 0.3 million tons increase in demand. In all, the total demand for waste paper, including net exports, was 13.5 million tons in 1972 and 14.9 million tons in 1973, up 1.4 million tons or 10 percent. Never before had the industry experienced a demand increase for waste paper of 1 million tons in 1 year.

In addition, new capacity to utilize waste paper was committed by the industry and coming on-stream in 1974 and 1975. In fact, the American Paper Institute annual capacity survey forecast the use of 15.8 million tons of waste paper in domestic mills by 1975,[*] and MRI estimates net exports of 0.9 million tons for a total demand for 16.7 million tons, up nearly another 2 million tons in 2 years. However, demand suddenly collapsed in late 1974, and it appears that about 2 years will elapse before the recycling recurrence will resume with strength.

The paper industry's recycling rate showed a "turnaround" in 1973--from 20.4 percent in 1972 to 21.3 percent in 1973; in 1975, the rate of recycling will be at the 1973 level. Then a period of uncertainty develops. If the industry brings on substantial new virgin fiber processing capacity, the recycling rate will remain flat or decline slightly until the early 1980's. However, we believe it is more likely that companies will combine recycling capability with virgin fiber capacity, especially for the use of old corrugated containers (in linerboard and corrugating medium); also newsprint deinking to make newsprint should expand substantially in the future. This will mean years of pressure on the industry to recover higher percentages of the key waste paper grades. At the same time, net exports of waste paper will likely continue strong in the face of a worldwide tight virgin fiber supply situation.

Under this scenario, and the fact that our previous forecast of a turnaround appears to have been "confirmed,"[**] we developed a forecast of waste paper demand in the paper industry from 1973 to 1990, by major grade category (Table 105). This forecast shows that recovery of waste paper from the gross waste generated will climb from 14.3 million tons in 1973 to 27.3 million tons in 1990, an increase of 91 percent in 17 years. In addition, we estimate that net exports will rise from 0.6 million tons in 1973 to 1.6 million tons in 1990 (Table 106). With an additional usage of 0.4 million tons in other recycling applications, the total demand for waste paper will be 32.5 million tons in 1990 (Refer to Table 90).

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[*] "API Capacity 1972-1975, Paper, Paperboard, Wood Pulp," American Paper Institute, 1973.

[**] "Paper Recycling, the Art of the Possible, 1970-1985," op. cit.

TABLE 105

ESTIMATED USAGE OF WASTE PAPER FOR RECYCLING IN THE PAPER INDUSTRY BY MAJOR GRADE CATEGORY, 1972-1990

(In thousand tons)

Waste Paper Grade	1970	1971	1972	1973	1975	1980	1985	1990
Mixed Grades	2,639	2,776	3,054	3,251	3,215	3,670	4,185	4,510
News--post-consumer	1,825	1,754	1,880	2,129	2,110	2,535	2,995	3,375
News--converting[a]	410	420	437	450	440	500	550	625
Total	2,235	2,174	2,317	2,579	2,550	3,035	3,545	4,000
Corrugated--post-consumer	2,528	2,700	2,960	3,430	3,410	5,100	7,425	10,095
Corrugated--cuttings[b]	1,552	1,577	1,762	1,861	1,820	2,305	2,870	3,565
Total	4,080	4,277	4,722	5,291	5,230	7,405	10,295	13,650
Deinking Grades and Pulp Substitutes	3,067	3,097	3,037	3,198	3,165	3,750	4,440	5,180
Grand Total	12,021	12,324	13,230	14,317	14,160	17,860	22,465	27,340
Paper Demand	57,835	59,440	64,356	67,122	66,490	79,360	93,565	109,240
Recycling Rate	20.8	20.7	20.4	21.3	21.3	22.5	24.0	25.0

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[a] Based upon calculated printing scrap recovery of 2.8 percent of newsprint demand plus overissue news at 1.4 percent of newsprint demand.

[b] Based upon 11.0 percent of containerboard mill production (domestic use); calculated from McClenahan data for cuttings 1969, 1970.

TABLE 106

WASTE PAPER IMPORTS AND EXPORTS, 1960 TO 1990

(In thousand tons)

Year	Exports	Imports	Net Exports
1960	153	NA	153
1961	206	NA	206
1962	209	NA	209
1963	230	NA	230
1964	272	87	185
1965	292	108	184
1966	246	113	133
1967	262	86	176
1968	253	93	160
1969	289	88	201
1970	408	67	341
1971	419	68	351
1972	415	88	327
1973	683	87	596
1974 est.	1,307	87	1,220
1975	1,000	100	900
1980	1,200	100	1,100
1985	1,400	100	1,300
1990	1,650	100	1,550

Source: "Statistics of Paper and Paperboard 1974," American Paper Institute, 1974; forecast by Midwest Research Institute.

The grades that will contribute most to the increase in recycling are old newspapers and corrugated containers. As indicated in Table 105, the demand for old newspapers (as opposed to converting scrap) will increase from 2.1 million tons in 1973 to 3.4 million tons in 1990, an increase of 62 percent. Old corrugated container demand will go from 3.4 million tons in 1973 to 10.1 million tons in 1990, or 197 percent. However, both of these increases are less than would be possible if external actions stimulate the industry. Overall the forecast recycling rates led to an unspectacular resurgence of recycling in the paper industry.

The details of this forecast are developed in a different way in a summary table for 1973 and 1985, which combines paper production in the USA by grade with the forecast of waste paper use in each paper grade detailed by the waste paper grade (e.g., news, corrugated etc.) itself (Table 107). What this table shows and our analysis confirms is that most grades that have used waste paper will continue to do so, but only a few will show significant increases in the rate of recycling--relating once again the key role that news and corrugated will play.

Overall, we have calculated a recycling rate of 24 percent in 1985 (22.5 million tons of waste paper use) versus 21.3 percent in 1973 (14.3 million tons). Analysis of this table shows where increased recycling will take place, and where it will not (a significant factor in itself).

The most notable increases will take place in:

* newsprint

* tissue

* kraft linerboard

* recycled linerboard

* recycled corrugating material

* "other" containerboard

However, the long-term historic uses of waste paper--combination boxboard (holding boxboard, set up boxboard, and other boxboard)--will continue to be in relative decline in the years ahead. Nothing in recent statistics and industry activities would indicate that recycled boxboard will recover and become more important vis-a-vis its competition (bleached and unbleached kraft paperboard) in the years ahead.*

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* More detailed development of the recycling forecasts is given in Appendix E for newsprint, linerboard, corrugating medium, and boxboard.

TABLE

WASTE PAPER USAGE AND DISTRIBUTION IN THE PAPER INDUSTRY BY PAPER GRADE AND TYPE OF WASTE PAPER, 1973 AND 1985

(In thousand tons and percent)

Grade Category	1973 Demand	% Waste Paper Use	Total Waste Paper Use	Mixed	News	Corrugated	Pulp Subs & High Grade Deinking	1985 Production	% Waste Paper	Total Waste Paper Use	Mixed	News	Corrugated	Pulp Subs & High Grade Deinking
Paper--Demand														
Newsprint--production	3,413	14.0	490	7	483	--	--	4,700	22.0	1,030	30	1,000	--	--
Newsprint--net imports	7,313	--	--	7	483	--	--	8,600	--	--	--	--	--	--
Printing, Writing and Related	13,334	7.0	938	44	--	--	893	19,750	7.5	1,480	150	--	--	1,330
Unbleached Kraft and Ind. Conv.	4,025	4.5	263	47	14	15	187	5,260	5.7	440	90	20	45	285
Special Ind. and Other	1,797							2,420						
Tissue	3,933	30.0	1,179	98	98	125	858	5,270	35.4	1,900	170	190	260	1,280
Total Paper[f]	33,748	8.5	2,870	196	595	140	1,938	46,000	21.1	4,850	440	1,210	305	2,895
Paperboard--Production														
Containerboard--solid wood pulp														
Linerboard	11,067	--	449	50	1	355	44	15,840	13.3	2,110	200	3	1,810	100
Corrugating Medium	4,127	20.6	849	77	19	747	7	5,500	20.0	1,100	70	15	1,005	10
Other Containerboard[c]	2,392	-- [b]	-- [b]	--	--	--	--	3,600	neg.	neg.	--	--	--	--
Total Containerboard	17,496	7.4	1,298	127	20	1,102	51	24,940	12.9	3,210	270	15	2,815	110
Boxboard--solid wood pulp	4,191	neg.	--	--	--	--	--	5,600	neg.	neg.	--	--	--	--
Recycled Paperboard[a]														
Linerboard	289	108.0	310	25	0	273	12	1,760	108.0	1,900	150	--	1,675	75
Corrugating Medium	1,128	80.0	902	14	8	875	5	2,600	80.0	2,080	40	10	2,020	10
Chip and Fillerboard	307	115.0	353	100	79	107	67	400	115.0	460	130	100	140	90
Other Containerboard[c]	1,386	107.0	1,480	329	337	611	203	2,200	107.0	2,355	520	540	965	330
Folding Boxboard	2,522	115.0	2,900	820	650	879	551	2,480	115.0	2,850	800	625	885	540
Set-up Boxboard	465	115.0	535	151	120	162	102	440	115.0	505	146	110	160	95
Other Folding Boxboard[d]	1,788	116.0	2,080	570	443	907	160	1,980	116.0	2,300	630	490	1,005	175
Total Recycled Paperboard	7,885	109.0	8,560	2,009	1,637	3,814	1,100	11,860	105.0	12,450	2,410	1,875	6,850	1,315
Total Paperboard--Production	29,572	33.0	9,858	2,136	1,657	4,916	1,151	42,400	37.0	15,660	2,680	1,890	9,665	1,425
Paperboard Adj. for Exports--Demand	27,327							39,150						
Other Paper and Paperboard--Demand														
Wet Machine/Board	134	80.6	1,591	919	327	235	109	145	65.0	95	75	0	10	10
Construction Paper	1,840							2,270	71.0	1,610	985	280	310	35
Insulating and Hard-Pressed Board	4,073	--	--	--	--	--	--	6,000	-	--	--	--	--	--
Total Other	6,047	26.3	1,591[e]	919	327	235	109	8,415	20.0	1,705	1,060	280	320	45
Molded Pulp and Fiber Pipe			-- [e]						--	250	5	165	5	75
Grand Totals	69,367							96,815						
Adj. for Paperboard Export--Demand	67,122	21.3	14,319	3,251	2,579	5,291	3,198	93,565	24.0	22,465	4,185	3,545	10,295	4,640

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a/ The calculation procedure was as follows: The total production and waste paper use came from API "Statistics of Paper and Paperboard, 1974" and "Capacity, 1973-1976: Paper, Paperboard, Woodpulp." The distribution of waste paper by paperboard grade for the recycled paperboard category was derived from McClenahan, "Consumption of Paper Stock by United States' Mills in 1969, and 1970." This source gave the basis for columns 2 through 7 in "Recycled Paperboard." However, "Other Folding Boxboard" was used to balance the total recycled paperboard grades for total waste paper usage, i.e., the waste paper distribution for "Other Folding Boxboard" was derived by difference, not calculation.

b/ Franklin Associates calculated usage of waste paper in terms of linerboard production for domestic use; in actuality, some waste paper is also used in the "Other Containerboard" grades (kraft), but this use could not be calculated.

c/ "Other Containerboard" consists of: tube, can and drum--11%, gypsum wallboard--27%, linerboard export--50%, all other 12%. The breakdown is about 63% solid woodpulp type and 37% recycled paperboard grades.

d/ "Other Boxboard" consists of: tube, can and drum--33%, exports--17%; all other uses, 50%. The breakdown is about 20% solid wood pulp and 80% recycled paperboard grades.

e/ API includes in "Other Paper" the waste paper in molded pulp and fiber pipe, about 250,000 tons per year.

f/ Does not add to totals because data source does not make import-export adjustments grade by grade.

Source: Midwest Research Institute.

Thus, our present forecast of recycling is not as optimistic as it was 2 years ago.* However, these two forecasts differ in one key respect--our earlier forecast assumed that outside focus, e.g., federal intervention, would bring about rapid increases in recycling; the present forecast relies wholly on recent trends within the industry--which admittedly are much more favorable to recycling than 2 years ago, but are going to bring gradual, rather than rapid, change to the raw materials patterns of the paper industry.

Because corrugated containers represent the "best" post-consumer waste paper grade (along with newspapers), we developed more detail on the trend in recovery of old corrugated (Table 108). A predictable ratio of clippings will be recovered, based on tonnage processed through box-making plants. The use of old corrugated containers will increase from 3.4 million tons in 1973 to 10.1 million tons in 1990. Overall, the recovery of corrugated will increase from 5.3 million tons in 1973 to 13.6 million tons in 1990, up 156 percent. If this occurs as forecast, then corrugated recovery will represent 50 percent of all waste paper recovered for recycling in the paper industry in 1990 compared to 37 percent in 1973. Also, this level of corrugated recovery will mean a recovery rate of 42.1 percent of domestic containerboard consumption in 1990, compared to 31.3 percent in 1973 (Table 108). Thus, the recovery techniques of necessity will have to become more sophisticated and efficient.

A recycling profile of the total paper industry for a 50-year span, from 1940 to 1990, shows history repeating itself in a sense (Table 109, Figure 32). The rate of recycling is forecast to bottom out at 20.4 percent in 1972 and rise to 25.0 percent by 1990. In 1954, the recycling rate was 25.0 percent, so that reversal to "equivalent points" will take 40 years, of which 22 are in decline and 18 are in rising rates of recycling.

The Recoverability of Waste Paper for Recycling

To determine the forecast role that recycling will play in paper recovery by 1990, we also determined the amount of waste paper that could reasonably be removed from the waste stream. This calculation followed a detailed step wise procedure, including a breakdown of the general secondary waste paper grade classification. The base year for this calculation was 1985. Each major paper product category is classified into five broad grades: mixed, news, corrugated, deinking (bleached) and pulp substitutes. These designations are those commonly used to classify waste paper into recycling grades.

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* "Paper Recycling--the Art of the Possible, 1970-1985," op. cit.

TABLE 108

COMPARATIVE RECYCLING OF CONTAINERBOARD, 1969-1990

Year	Total Waste Paper Used- Domestic	U.S.A. Recycling Rate- %	Total Container Recycled	Container % of Waste Paper	Container Increase % Over 1969	Container Clippings[b]	Post-Consumer Containers	Containerboard Production[a]	Container Recovery Rate- %
1969	11,969	20.3	4,415	36.9	--	1,559	2,856	14,396	30.7
1970	12,021	20.7	4,080	33.9	-8	1,552	2,528	13,964	29.2
1971	12,323	20.7	4,277	34.7	-3	1,578	2,528	13,964	29.8
1972	13,132	20.4	4,722	36.0	+7	1,762	2,960	16,019	29.5
1973	14,318	21.3	5,291	37.0	+20	1,862	3,429	16,928	31.3
1975	14,160	21.3	5,230	36.9	+18	1,820	3,410	16,550	31.6
1980	17,860	22.5	7,405	41.5	+68	2,305	5,100	20,950	35.3
1985	22,465	24.0	10,295	45.8	+133	2,871	7,424	26,100	39.4
1990	27,340	25.0	13,650	49.9	+209	3,567	10,083	32,430	42.1

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a/ Domestic use linerboard, corrugating medium, container chipboard.

b/ Actual for 1969 and 1970 based upon IPC data; calculated at 11% containerboard, 1971 to 1990 based on 1969-1970 actual.

Source: American Paper Institute data, Institute of Paper Chemistry; Midwest Research Institute estimates (1975-1985).

TABLE 109

PAPER RECYCLING IN THE PAPER INDUSTRY, 1940 TO 1990

(In thousand tons)

Year	Waste Paper[a]	Waste Paper[b]	Paper Consumption	Percent Recycle[a]	Percent Recycle[b]
1940	4,668		16,757	27.9	
1941	6,075		20,421	29.7	
1942	5,495		19,780	27.8	
1943	6,368		19,437	32.8	
1944	6,859		19,445	35.3	
1945	6,800		19,665	34.6	
1946	7,278		22,510	32.3	
1947	8,009		24,749	32.4	
1948	7,585		26,083	29.1	
1949	6,600		24,695	26.7	
1950	7,956		29,012	27.4	
1951	9,070		30,561	29.7	
1952	7,881		29,017	27.2	
1953	8,531		31,360	27.2	
1954	7,857		31,379	25.0	
1955	9,041		34,719	26.0	
1956	8,836		36,495	24.2	
1957	8,493		35,270	24.1	
1958	8,671		35,119	24.7	
1959	9,414		38,725	24.3	
1960	9,031		39,138	23.1	
1961	9,018		40,312	22.4	
1962	9,075		42,216	21.5	
1963	9,613		43,715	22.0	
1964	9,843		46,384	21.2	
1965	10,231		49,102	20.8	
1966	10,564		52,680	20.1	
1967	9,888		51,945	19.0	
1968	10,222		55,664	18.4	
1969	10,939	11,969	58,915	18.6	20.3
1970	10,059	12,021	57,940	18.3	20.7
1971	10,997	12,323	59,557	18.5	20.7
1972	11,269	13,132	64,386	17.5	20.4
1973		14,318	67,240		21.3
1975		14,160	66,490		21.3
1980		17,860	79,360		22.5
1985		22,465	93,565		24.0
1990		27,340	109,240		25.0

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a/ U.S. Bureau of Census data.

b/ American Paper Institute data 1969-73; MRI 1975-1990. Includes waste paper in molded pulp, pipe, etc.

Source: "Statistics of Paper and Paperboard 1974," American Paper Institute, 1974. (1940-1973); Midwest Research Institute Forecasts.

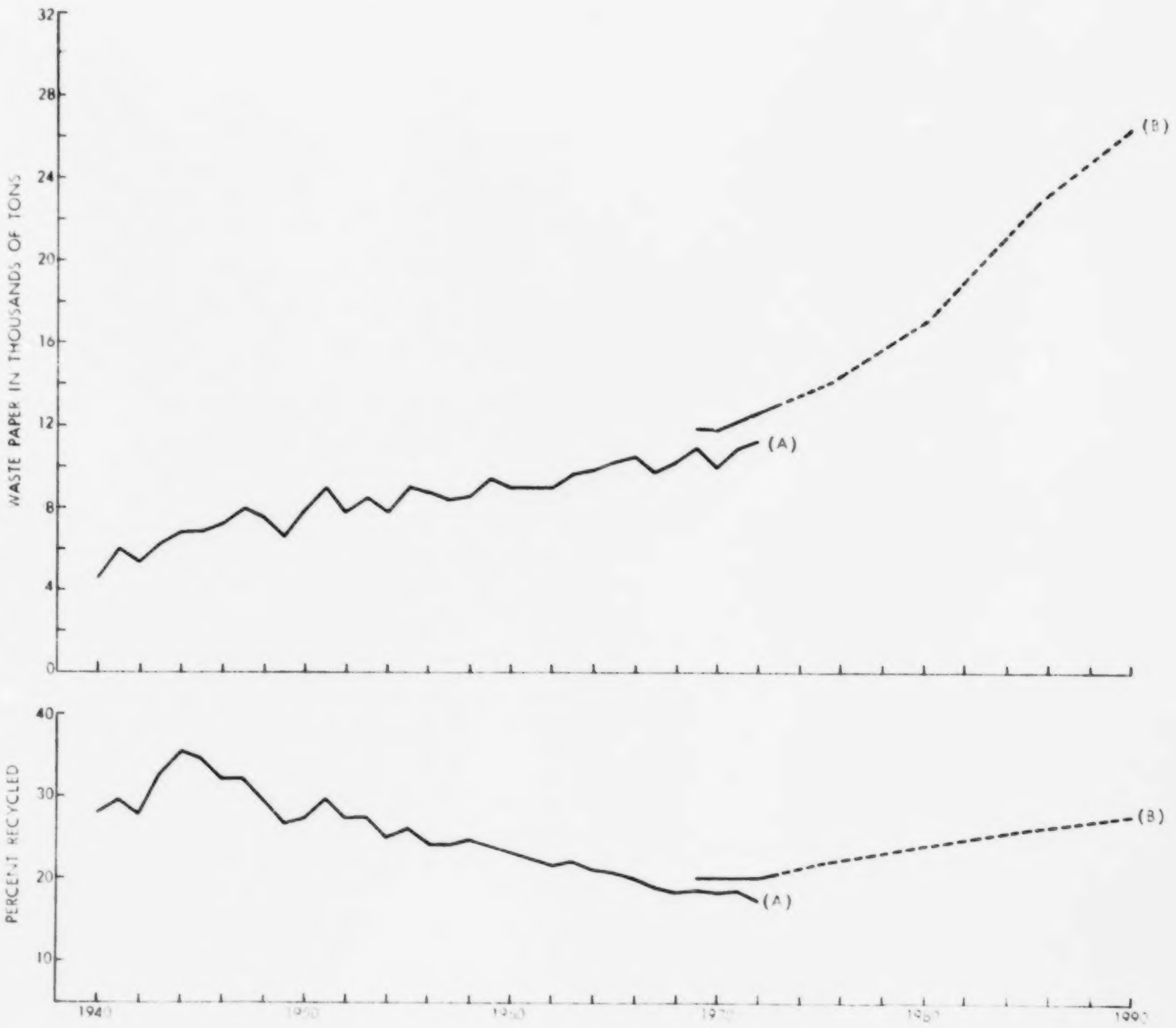

Figure 32 - Paper Recycling in the Paper Industry, 1940-1990

The breakdown by grade follows historical patterns of paper consumption and use. No attempt was made to determine potential waste paper grade precisely, rather the total available waste was classified into one value. The calculated distribution for 1972 is given in Table 110. One step was to determine recoverability of these products as waste paper grades by source converting, household and nonhousehold. This was done as follows (Table 110). Total waste available was grouped by paper grade; converting scrap was then displayed along with household and nonhousehold waste generated. Then an estimate of the recovery potential for each grade by source was made. Converting scrap as calculated previously is largely recovered for recycling purposes. The remaining "net" waste paper is post-consumer waste and can be recovered in varying degrees, e.g., newspapers from homes are 55 percent recoverable; corrugated containers from businesses 60 percent recoverable.*

The next calculation was the determination of the amount of post-consumer waste that is recoverable and by difference what is unrecoverable. The SMSA was considered a geographically "acceptable" potential source in which waste paper could be recovered economically, i.e., with a population concentration and density conducive to commercial recovery operations. About 70 percent of the U.S. population is in SMSA's and a larger proportion of waste paper is generated in SMSA's as reflected in per capita paper consumption figures. We estimated that up to 80 percent of post-consumer waste paper products would occur in SMSA's. If in general, 60 percent of a grade is recoverable in SMSA's and 20 percent outside is recoverable, we have an estimate (0.80 x 0.60 + 0.20 x 0.20 = 52 percent). We used this general approach for key bulk grades like news and corrugated. However, we had to apply more general estimates to the other products which should be treated only as approximations (Table 110).

The next step was to determine what proportion will actually be recovered, based on our previous forecasts. This again was a judgment based on the paper industry's use of selected waste paper grades on a historical and forecast basis. Actual recovery (total fiber uses) was

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* A careful study of Table 110 will show that these are our best estimates and vary from a low of 10 percent to a high of 60 percent for postconsumer waste depending upon the nature of the product and whether it occurs in households or nonhousehold locations.

TABLE 110

ESTIMATED WASTE PAPER RECOVERY POTENTIAL AND FORECAST OF ACTUAL RECOVERY FOR ALL FIBER USES, 1985

(In thousand tons and ratio)

Trade Classification	(1) Total Available	(2) Recovery Potential (Ratio)	(3) Total Recovery Potential	(4) Unrecoverable	(5) Actual Recovery	(6) Potential Recovery (3) ÷ (5)	Distribution of Recovery by Grade and Source (7) Mixed	(8) News	(9) Container	(10) Pulp Subs	(11) Deinking
Newsprint	13,150	0.535	7,000	6,150	4,760	68	890	3,770		50	50
Converting Scrap	550	1.00	550	0	550	100		500		50	
Household Waste	11,350	.55	6,250	5,100	4,110	66	890	3,170			50
Nonhousehold Waste	1,250	.15	200	1,050	100	50		100			
Printing Paper	11,300	0.32	3,580	7,720	2,325	65	900			680	245
Converting Scrap	1,500	0.95	1,425	75	1,425	100	400			525	
Household Waste	5,900	0.20	1,180	4,720	150	13	100				50
Nonhousehold Waste	3,900	0.25	975	2,925	750	77	400			155	195
Fine Paper	6,350	0.31	1,980	4,370	1,640	83	150			900	590
Converting Scrap	600	1.00	600	0	600	100				550	50
Household Waste	1,150	0.20	230	920	90	39	50				40
Nonhousehold Waste	4,600	0.25	1,150	3,450	950	83	100			350	500
Industrial Converting and Packaging Paper	7,550	0.32	2,405	5,145	980	41	480			450	50
Converting Scrap	400	0.95	380	20	380	100	80			300	
Household Waste	4,650	0.30	1,400	3,250	150	11	150				
Nonhousehold Waste	2,500	0.25	625	1,875	450	72	250			150	50
Tissue	3,350	0.18	605	2,745	290	48	50			200	40
Converting Scrap	250	0.95	240	10	240	100				200	40
Household Waste	2,150	0.10	215	1,935	0	0					
Nonhousehold Waste	950	0.15	150	800	50	33	50				
Total Paper	41,700	0.37	15,570	25,130	9,995	64	2,470	3,770		2,280	1,475
Converting Scrap	3,300	0.97	3,195	105	3,195	100	480	500		1,625	590
Household Waste	25,200	0.37	9,275	15,925	4,600	50	1,190	3,170		0	140
Nonhousehold Waste	13,200	0.23	3,100	10,100	2,300	74	800	100		655	745
Containerboard	25,600	0.61	15,700	9,900	11,385	73	460		10,925	615	20
Converting Scrap	2,870	1.00	2,870	0	2,870	100			2,870		
Household Waste	1,600	0.10	160	1,440	35	22	10		25		
Nonhousehold Waste	21,130	0.60	12,670	8,460	8,480	67	450		8,035		

TABLE 110 (Concluded)

ESTIMATED WASTE PAPER RECOVERY POTENTIAL AND FORECAST OF ACTUAL RECOVERY FOR ALL FIBER USES, 1985

(concluded)

Folding Boxboard and Setup Boxboard	5,850	0.33	1,905	3,945	995	52	995				
Converting Scrap	1,050	0.90	945	105	945	100	945				
Household Waste	3,850	0.20	770	3,080	10	1	10				
Nonhousehold Waste	950	0.20	190	760	40	21	40				
Milk and Food Service	1,950	0.30	590	1,360	310	53	20			270	20
Converting Scrap	250	1.00	250	0	250	100				250	
Household Waste	1,200	0.20	240	960	10	4	10				
Nonhousehold Waste	500	0.20	100	400	50	50	10			20	20
Other Containerboard and Boxboard	3,400	0.28	960	2,440	515	54	170			345	
Converting Scrap	400	0.90	360	40	360	100	60			300	
Household Waste	1,500	0.20	300	1,200	10	3	10				
Nonhousehold Waste	1,500	0.20	300	1,200	145	48	100			45	
Total Paperboard	36,800	0.52	19,155	17,645	13,205	69	1,645		10,925	615	20
Converting Scrap	4,550	0.97	4,425	145	4,425	100	1,005		2,870	550	0
Household Waste	8,150	0.18	1,470	6,680	65	4	40		25	0	0
Nonhousehold Waste	24,100	0.55	13,260	10,820	8,715	66	600		8,030	65	20
Construction, Insulating and Hand Dressed Board	1,450	0.54	780	670	650	83	320			300	30
Converting Scarp	700	0.90	630	70	630	100	300			300	30
Household Waste	300	0.20	60	240	0	0					
Nonhousehold Waste	450	0.20	90	360	20	22	20				
Grand Total - All Grades	79,950	0.44	35,505	44,445	23,850	67	4,435	3,770	10,925	3,195	1,525
Converting Scrap	8,570	0.96	8,250	320	8,250	100	1,785	500	2,870	2,475	620
Household Waste	33,650	0.32	10,805	22,845	4,565	42	1,230	3,170	25	0	140
Nonhousehold Waste	37,730	0.44	16,450	21,280	11,035	67	1,420	100	8,030	720	765

Note: Includes paper recovered for recycling, for molded pulp products, for other uses, and for net exports. Fiber recovery in solid waste management systems of 1,200,000 tons is included; recovery for energy is excluded. Exports are calculated using the same grade structure and percentages as domestic use, since no documentation of export grade structure is available. The year 1985 was selected as the base year to make the detailed calculations. However, the details presented here are estimates only and should not be construed as more than approximations; this is particularly true of source and detailed grade recovery data. While this represents estimates, the summary results appear to be generally valid and representative based upon the forecasts made which preceded these estimates and calculations.

Source: Midwest Research Institute.

then distributed on a grade-by-grade basis by source. The result was a highly detailed approximate of waste paper recovery in 1985 to meet the recycling, modeled pulp, and export demand earlier forecast. (We believe this distribution is usable in summary form, but should not be applied on a detailed basis because focal data was virtually nonexistent).

Once the 1985 calculation was complete, the same procedure was carried out on an aggregated basis for 1972 (Table 111); 1975 (Table 112); 1980 (Table 113); 1990 (Table 114). The impact of post-consumer waste recovery from the home and businesses becomes apparent if 1972 and 1990 are contrasted: recovery of all grades (mainly news) for households was 2.9 million tons in 1972 and will be 5.0 million tons in 1990. For nonhousehold sources, the recovery was 5.2 million tons in 1972 and rose to 14.3 million tons in 1990 (all grades but old corrugated containers are a key factor).

Summary of the Impact of Recycling on Solid Waste

Likewise, the residual waste--that which has no fiber recovery value was then calculated. Excluding resource recovery facilities that convert paper to an energy product (but including fiber recovery from solid waste management system), the net waste in resource recovery systems or processed for disposal was calculated. This value is 41.5 million tons in 1972, rising to 64.6 million tons in 1990, an increase of 56 percent or 23.1 million tons. At the same time, the waste paper generated is 55.0 million tons in 1972 rising to 93.6 million tons in 1990 an increase of 70 percent and 38.6 million tons. Thus, withdrawal of fiber as recycling or export material will lighten but not lower the direct burden on the solid waste management system. The trend is favorable, but the rate is lower than it might be under other circumstances. Increased paper recovery rates will impact favorably on the solid waste rate of growth, but the tonnage will continue to increase steadily with increasing consumption.

However, paper can also be utilized for other resource recovery options although recycling (including exports) is the most viable recovery option at the present time. To a lesser extent, other recovery options might reduce the amount of net waste paper disposed of by conventional disposal techniques--landfill and by incineration.

TABLE 111

ESTIMATED WASTE PAPER RECOVERY POTENTIAL AND ACTUAL RECOVERY FOR ALL FIBER USES, 1972

(In thousand tons and percent)

					Distribution of Recovery by Grade and Source					
Category	Total Available	Percent Recoverable	Recovery Potential	Actual Recovery	Mixed	News	Container	Pulp Subs	Deinking	Total Unrecovered
Total - Paper	29,450	37	10,985	6,620	1,755	2,385		1,545	935	22,830
Converting Scrap	2,200	97	2,135	2,135	298	437		1,050	350	65
Household Waste	18,450	37	6,825	2,895	887	1,918		0	90	15,555
Nonhousehold Waste	8,800	23	2,025	1,590	570	30		495	495	7,210
Total - Paperboard	24,600	51	12,505	6,510	1,180		4,880	425	25	18,090
Converting Scrap	3,100	97	3,010	2,887	715		1,762	385	25	213
Household Waste	6,300	18	1,135	30	30			0		6,270
Nonhousehold Waste	15,200	55	8,360	3,593	435		3,118	40		11,607
Total - Construction, Etc.	1,000	52	515	420	220			195	5	580
Converting Scrap	450	90	405	405	205			195	5	45
Household Waste	250	20	50	0						250
Nonhousehold Waste	300	20	60	15	15					
Total - All Categories	55,050	44	24,005	13,550	3,155	2,385	4,880	2,165	965	41,500
Converting Scrap	5,750	97	5,550	5,427	1,218	437	1,762	1,630	380	323
Household Waste	25,000	32	8,010	2,925	917	1,918	0	0	90	22,075
Nonhousehold Waste	24,300	43	10,445	5,198	1,020	30	3,118	535	495	19,102

Note: Includes paper recovered for recycling in the paper industry for use in molded pulp products, for other uses and net exports. Fiber recovered in Solid Waste Management Systems of 50,000 tons is included; recovery for energy is excluded. Exports are claculated at the same grade structure and percentages as domestic use since no documentation of export grade structure is available. This table was constructed and calculated from detailed data developed for 1985, and adjusted to 1972.

Source: Midwest Research Institute.

TABLE 112

ESTIMATED WASTE PAPER RECOVERY POTENTIAL AND ACTUAL RECOVERY FOR ALL FIBER USES, 1975

(In thousand tons and percent)

Category	Total Available	Percent Recoverable	Recovery Potential	Actual Recovery	Distribution of Recovery by Grade and Source					Total Unrecovered
					Mixed	News	Container	Pulp Subs	Deinking	
Total Paper	30,950	37	11,540	7,340	1,915	2,725		1,690	1,055	23,610
Converting Scrap	2,350	97	2,280	2,280	300	440		1,140	400	70
Household Waste	19,150	37	7,085	3,270	925	2,255		0	90	15,880
Nonhousehold Waste	9,450	23	2,175	1,790	690	30		550	565	7,660
Total Paperboard	24,900	51	12,765	7,315	1,275		5,590	445	5	17,585
Converting Scrap	3,150	97	3,055	2,925	700		1,820	400	5	225
Household Waste	6,100	18	1,100	25	25		0	0		6,075
Nonhousehold Waste	15,650	55	8,610	4,365	550		3,770	45		11,285
Total Construction, Etc.	1,100	52	570	495	250			215	30	605
Converting Scrap	500	90	450	450	210			210	30	50
Household Waste	250	20	50	0	0			0		250
Nonhousehold Waste	350	20	70	45	40			5		305
Total All Categories	56,950	44	24,875	15,150	3,440	2,725	5,590	2,305	1,090	41,800
Converting Scrap	6,000	96	5,785	5,655	1,210	440	1,820	1,750	435	345
Household Waste	25,500	32	8,235	3,295	950	2,255	0	0	90	22,205
Nonhousehold Waste	25,450	43	10,855	6,200	1,280	30	3,770	555	565	19,250

Note: Includes paper recovery for recycling in the paper industry, for use in molded pulp products, for other uses, and net exports. Fiber recovery in solid waste management systems of 300,000 tons is included; recovery for energy is excluded. Exports are calculated at the same grade structure and percentages as domestic use since no documentation on grade structure is available. This table was constructed and calculated from detailed data developed for 1985, and adjusted to 1975.

Source: Midwest Research Institute.

TABLE 113

ESTIMATED WASTE PAPER RECOVERY POTENTIAL AND ACTUAL RECOVERY FOR ALL FIBER USES, 1980

(In thousand tons and percent)

Category	Total Available	Percent Recoverable	Recovery Potential	Actual Recovery	Distribution of Recovery by Grade & Source					
					Mixed	News	Container	Pulp Subs	Deinking	Unrecovered
Total Paper	36,150	37	13,515	8,595	2,175	3,240		1,930	1,250	27,555
Converting Scrap	2,850	97	2,765	2,765	365	500		1,400	500	85
Household Waste	22,050	37	8,160	3,860	1,050	2,690		0	120	18,190
Nonhousehold Waste	11,250	23	2,590	1,970	760	50		530	630	9,280
Total Paperboard	31,550	51	16,140	9,895	1,450		7,905	520	20	21,655
Converting Scrap	3,850	97	3,735	3,660	870		2,305	485	0	190
Household Waste	7,650	18	1,375	60	50		10	0	0	7,590
Nonhousehold Waste	20,050	55	11,030	6,175	530		5,590	35	20	13,875
Total Construction	1,250	54	670	560	280			260	20	690
Converting Scrap	600	90	540	540	260			260	20	60
Household Waste	300	20	60	0	0					300
Nonhousehold Waste	350	20	70	20	20					330
Total All Categories	68,950	44	30,235	19,050	3,905	3,240	7,905	2,710	1,290	49,900
Converting Scrap	7,300	96	7,040	6,965	1,495	500	2,305	2,145	520	335
Household Waste	30,000	32	9,505	3,920	1,100	2,690	10	0	120	26,080
Nonhousehold Waste	31,650	43	13,690	8,165	1,310	50	5,590	565	650	23,485

Note: Includes paper recovered for recycling in the paper industry, for use in molded pulp products, for other uses, and net exports. Fiber recovered in solid waste management systems of 650,000 tons is included; recovery for energy is excluded. Exports are calculated using the same grade structure and percentages as domestic use since no documentation on grade structure is available. This table was constructed and calculated from detailed data developed for 1985, and adjusted to 1980.

Source: Midwest Research Institute.

TABLE 114

ESTIMATED WASTE PAPER RECOVERY POTENTIAL AND ACTUAL RECOVERY FOR ALL FIBER USES, 1990

(In thousand tons and percent)

					Distribution of Recovery by Grade & Source					
Category	Total Available	Percent Recoverable	Recovery Potential	Actual Recovery	Mixed	News	Container	Pulp Subs	Deinking	Total Unrecovered
Total Paper	47,850	37	17,825	11,315	2,645	7,625		2,700	1,715	36,535
Converting Scrap	3,800	97	3,685	3,685	540	625		1,850	650	115
Household Waste	28,700	37	10,620	4,965	1,265	3,500		0	200	23,735
Nonhousehold Waste	15,350	23	3,520	2,665	840	3,500		850	865	12,685
Total Paperboard	44,150	52	23,150	16,995	1,775		14,470	725	25	27,155
Converting Scrap	5,450	97	5,285	5,285	1,100		3,565	620		165
Household Waste	9,250	18	1,665	70	35		35	0		9,180
Nonhousehold Waste	29,450	55	16,200	11,640	640		10,870	105	25	17,810
Total Construction	1,650	52	855	690	345			315	30	960
Converting Scrap	750	90	675	675	330			315	30	75
Household Waste	350	20	70	0						350
Nonhousehold Waste	550	20	110	15	15					535
Total All Categories	93,650	45	41,840	29,000	4,785	4,235	14,470	3,740	1,770	64,650
Converting Scrap	10,000	96	9,645	9,645	1,990	625	3,565	2,785	680	355
Household Waste	38,300	32	12,355	5,035	1,300	3,500	35	0	200	33,265
Nonhousehold Waste	45,350	44	19,840	14,320	1,495	110	10,870	955	890	31,030

Note: Includes paper recovered for recycling in the paper industry, for use in molded pulp products, for other uses and net exports. Fiber recovered in solid waste management systems of 2,500,000 tons is included; recovery for energy is excluded. Exports are calculated at the same grade structure and percentages as domestic use since no documentation of export grade structure is available. This table was constructed and calculated from detailed data developed for 1985 and adjusted to 1990.

Source: Midwest Research Institute.

Other Resource Recovery Options and Recovery Mechanisms for Paper to 1990

The most viable resource recovery options for waste paper or uses of recovered paper are:

(1) Recycling in the paper industry (in linerboard, newsprint, etc.);

(2) Recycling in other fiber products (molded pulp, insulation, pipe, etc.);

(3) Recycling outside the U.S.--exports;

(4) Recovery of the heat content of paper (fuel, conversion to energy).

In addition, the recovery mechanisms that apply are as follows:

(1) "Traditional" source separation for recycling:

  (a) at industrial paper converting plants;

  (b) at wholesale, retail, industrial plants; and

  (c) via "newspaper" drives.

(2) Collection and recovery within solid waste management systems:

  (a) municipal/private collection programs of news and/or old corrugated via householder separation from waste

  (b) deposit at special collection centers;

  (c) mechanical or hand separation at transfer stations or disposal sites; and

  (d) mechanical separation of fibers from mixed waste streams at comprehensive central waste processing facilities.

By far the most important recovery use is recycling of waste paper in the paper industry and export. And, the most important mechanism of recovery for these uses is "traditional" source separation programs. We estimate that all paper grades (except a small amount of old corrugated and old newspapers) is recovered via traditional source separation. Very little recovery is directly associated with a solid waste management system.

However, in the future,"piggy back" collection programs for newspapers and old corrugated will get much greater attention. Already about 100 communities in the U.S. have curbside newspaper collection programs under way. Paper companies committed to recycling of newspapers will have to increasingly seek their waste paper via community solid waste management systems--both voluntary and ordinance required programs.[*] These are viable options and MRI believes they will spread rapidly across the nation as the demand for old newspapers and corrugated containers increases faster than the traditional recovery techniques can supply them. The actual tonnage recovered via this technique in 1972 is not known. However, we estimate that by 1975, a total of 300,000 tons will be recovered via home separation and curbside collection. By 1990, this amount could increase to 2 million tons or about 7 percent of waste paper recovered for all recycling purposes.

In addition, by 1990, mechanical separation systems (such as wet pulping and/or dry mechanical processing) will account for another 500,000 tons fiber recovery. In all then, 2.5 million tons of waste paper will be recovered within solid waste management systems for recycling (out of a total of 29.0 million tons). In fact, our estimates may even look very modest for this recovery mechanism in the future, even though recovery directly from municipal waste streams is quite low today.[**]

Recovery of the Heat Content of Waste Paper

As outlined in Chapter II, central processing of mixed waste to recover the energy content of the organic fraction of waste will become very important in the future. Even with the removal of waste paper from the waste stream for recycling, a large quantity of waste paper will remain. Recovery of the Btu content of this paper (8,000 Btu per pound on a dry basis) will be highly significant. We believe the preferred recovery option will be to process mixed waste for use as a fuel in coal and oil-fired utility boilers. However, pyrolysis of the waste stream is also viable for producing a synthetic liquid fuel or gas and will also be practiced commercially after 1978.

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[*] See for example "Solid Waste Report," October 29, 1973, page 219, in which a program involving 118 communities in New Jersey will be incorporated in home-separated and curbside collection of newspapers in cooperation with Garden State Paper Company, a major deinker of old news to produce newsprint.

[**] We stand firm on this estimate even though many municipal recovery programs are in a shambles today following the recycling recession that hit in late 1974. This "glut" of supply will eventually dry up and the long-term trend to recovery will resume.

The amount of waste processed through central waste processing systems was determined in Chapter II. It remains only to determine how much of that organic fraction is paper. Since we have assumed all recovery for recycling takes place preferentially to using the waste as fuel, the calculation was straightforward, relating to the waste paper content in the average municipal solid waste stream.

Summary of Waste Paper Recovery Via All Options

An overall summary of waste paper recovery as it relates to the municipal waste stream is given for the period 1972 to 1990 in Table 115. This table shows that the tonnage of waste paper available in solid waste rises from 41.6 million tons in 1972 to 67.2 million tons in 1990. This translates to 32.0 percent of total municipal waste generation in 1972, increasing slightly to 33.6 percent of waste generated in 1990. (However, it declines slightly in the other years by comparison.)

The total municipal waste processed in central waste processing facilities will increase from 2.1 million tons in 1975 to 48.6 million tons in 1990. Assuming the waste paper content to be proportional to that calculated, the paper available for recovery processing in central facilities will increase from 0.6 million tons in 1975 to 16.7 million tons in 1990.

Of this amount, most will be processed for its heat (energy) value, and the amount of waste paper processed for energy will be 15.4 million tons in 1990. Almost all mechanical separation will occur in SMSA's, which might or might not have central waste recovery processing.

In all, the total useful recovery of waste paper from within solid waste management systems will be 0.95 million tons in 1975 and will increase to 17.9 million tons in 1990. If the energy recovery tonnage is added to the total recycled tonnage in 1990, then 44.3 million tons of 93.7 million tons of waste paper generated will be usefully recovered (or 47 percent). This is a large increase over 1972,in which 13.6 million tons were recovered from 55.1 million tons generated, or 25 percent (see Table 90 also).

In summary then, the burden of waste paper going to ultimate solid waste disposal sites will increase from 41.5 million tons in 1972 to 49.3 million tons in 1990, or a modest 19 percent. In the meantime, total waste paper recovery will rise by 22.8 percent and total paper consumption will rise by 70.6 percent in the same period. Thus, the advent of recycling rejuvenation and energy recovery will mean that the burden of waste paper on disposal systems will grow in tonnage,but decline appreciably in total impact compared to the potential,should resource recovery not take place.

TABLE 115

SUMMARY OF PAPER PROCESSING/RECOVERY FOR MIXED MUNICIPAL WASTE, 1972 TO 1990

(In Thousand Tons)

Category	1972	1975	1980	1985	1990
Total Solid Waste Generated[a]	130,000	140,000	160,000	180,000	200,000
Total Waste Paper Generated	55,050	56,950	68,950	79,950	93,650
Waste Paper Recovered Outside SWM Systems[b]	13,500	14,850	18,400	22,650	26,500
Paper Available in Solid Waste[c]	41,550	42,100	50,550	57,300	67,150
Percent Paper in Solid Waste	32.0	30.1	31.6	31.8	33.6
Solid Waste Processed in Central Facilities	Neg.	2,100	6,600	24,000	48,600
Paper Content	Neg.	650	2,100	7,650	16,350
Paper Recovered					
via Separation (50% efficiency)	Neg.	Neg.	50	200	500
via Energy Recovery	Neg.	650	2,000	7,250	15,350
Paper Not Recovered	Neg.	0	50	200	500
Total Waste Not Processed in Central Facilities	130,000	137,900	153,400	156,000	151,400
Paper Content	41,500	41,450	48,450	49,650	50,800
Paper Recovered (via separation)	50	300	600	1,000	2,000
Paper Not Recovered[d]	41,500	41,150	47,900	48,850	49,300
Total Paper Recovered[e]					
via Separation[e]	50	300	650	1,200	2,500
via Energy Recovery[e]	Neg.	650	2,000	7,250	15,350
Total Recovery - Paper[e]	50	950	2,650	8,450	17,850
Percent Recovered of Available in Solid Waste	0.1	2.2	5.2	14.7	26.6

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[a] Nominal Value from calculations in Chapter II.

[b] That recovered outside solid waste management systems via other separation techniques.

[c] Quantity of waste paper introduced into the municipal waste system for collection/recovery/disposal.

[d] Includes paper not recovered from central processing systems.

[e] That recovered from within solid waste management systems in metropolitan areas.

Source: Midwest Research Institute.

APPENDIX A

AN OVERVIEW OF TRENDS IN THE USE OF PACKAGING CONTAINERS FOR BEVERAGES, FOOD, AND OTHER PRODUCTS

INTRODUCTION

The purpose of this appendix is to give the background data on major packaging end uses where there is considerable intermaterials competition. It is from this analysis that the forecasts for specific materials (e.g., glass) used in beverage containers, food packaging and other uses were derived. The analysis which follows gives the detailed basis upon which our forecasts in previous chapters for glass containers, steel cans, aluminum cans and plastic containers were made.

BEVERAGE CONTAINERS

Soft Drink Containers

Soft drinks are one type of beverage which also include beer, distilled spirits and wine. All beverages accounted for 55.7 billion new containers and 86.5 billion filled containers in 1972, of which 25.8 billion new containers and 48.2 billion fillings were soft drinks.

The soft drink industry has been the most rapidly growing of all beverage markets. Soft drinks are predominately carbonated nonalcoholic beverages which are marketed to the consumer in glass containers or metal cans as well as dispensed from vending machines and fountains by mixing a syrup with water and carbonating. Consumption of soft drinks grew at a rate of 7.8 percent per year during the past decade.

Soft drinks are mixed and packaged by franchise dealers who purchase the syrup from manufacturers, such as Coca Cola, Pepsi Cola, Royal Crown, Seven-Up, and Dr. Pepper. The dealers bottle or can the soft drinks and distribute to diverse outlets within their franchised area. There are also a number of private label canners that package for larger supermarket chains.

Soft Drink Demand:* Increased soft drink consumption was spectacular in the 1960's, a time when the age group under 24 years was expanding rapidily. Soft drink marketers used advertising, new packaging and aggressive marketing techniques in developing the markets, concentrating on the under 24-year population segment which has the highest per capita consumption of soft drinks (Table A-1). With the rise in per capita disposable income, the rapid growth of fast food restaurants and drive-ins, introduction of a wide variety of flavors and low-calorie beverages and consumer preferences to favor soft drinks, the level of demand for soft drinks reached 3.54 billion cases (of 8-ounce equivalent bottles) of soft drinks in 1972. This demand is more than double the demand in 1962 (Table A-2). Consumption increased during this period from 213 containers (8-fluid ounces equivalent) per capita in 1962 to a level of 406 containers in 1972.

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* Whenever reference is made to "cases of 8-ounce equivalent," this measure is designed to put beverage packaged on one common size of container. In actuality, there are a variety of sizes and the 8-ounce equivalent basis should not be used as the basis for calculating actual use (number) of any given configuration (e.g., cans).

TABLE A-1

SOFT DRINK PER CAPITA CONSUMPTION BY AGE GROUP, 1972

Age	Soft Drink Sales: Billion Units[a]	Soft Drink Sales: Percent	Soft Drink Sales: 12-Ounce Units Per Capita
1 - 12	13.2	25.0	250
13 - 17	6.2	11.8	319
18 - 24	8.2	15.5	366
25 - 44	15.2	28.8	315
45 and over	9.9	18.9	162
Total	52.7	100.0	259

---

a/ 12-ounce equivalent units

Source: American Can Company, 1972.

There is strong evidence that this growth rate will not be maintained in the future. The principal conditions that stimulated growth in the past--an increasing rate of consumption and a large increase in the population under 24 years of age--no longer exist (Table A-3). The under 24 population is projected to increase in number only 5.8 percent between 1970 and 1980, compared to 16.8 percent between 1960 and 1970. Thus, most of the growth in demand from this age group will have to come from increasing per capita consumption, which will be more difficult to achieve. Because of the changing population mix, we are projecting that soft drink demand will slow from its past 7.8 percent per year rate to 5 percent per year through 1975, and 4.1 percent from 1975 to 1980. The growth rate will continue to slow to about 2.9 percent from 1980 to 1990, as shown in Figure A-1. Even with the reduced growth rates forecast, the slower population growth will cause per capita consumption to increase to a level of 636, 8-ounce equivalent containers by 1990 (Table A-2).

TABLE A-2

ANNUAL CONSUMPTION OF SOFT DRINKS 1950 TO 1990
(In equivalent cases and containers per capita)

Year	Total Cases 192 oz.*	Per Capita 8-oz Containers
1950	1,001,751,474	158.0
1960	1,476,544,000	192.0
1961	1,524,236,000	198.3
1962	1,667,514,000	213.4
1963	1,800,915,000	227.4
1964	1,948,590,000	242.9
1965	2,104,282,000	259.1
1966	2,352,587,000	287.0
1967	2,470,452,000	298.1
1968	2,777,035,000	331.6
1969	2,913,110,000	344.4
1970	3,096,635,000	362.8
1971	3,353,615,000	388.1
1972	3,541,417,000	406.4
1975	4,100,000,000	457.0
1980	5,020,000,000	527.0
1985	5,940,000,000	584.0
1990	6,860,000,000	636.0

AVERAGE ANNUAL GROWTH RATE (%)

Period	Cases
1950-1960	4.0
1960-1970	7.7
1962-1967	8.2
1967-1972	7.5
1972-1975	5.0
1975-1980	4.1
1980-1990	2.9

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* Sales expressed in cases of 24, 8-ounce containers.

Source: National Soft Drink Association, 1950-1972. MRI estimates 1972-1990.

TABLE A-3

U.S. POPULATION BY AGE, 1960 TO 1990

(In thousands)

Age Group	1960	1970	1975	1980	1990
Under 20	69,085	76,979	76,485	77,735	89,435
20 - 24	10,803	16,372	19,404	21,067	17,823
25 - 34	22,823	24,909	31,114	36,962	41,791
35 - 44	24,072	23,072	22,721	25,370	36,902
45 - 54	20,624	23,203	23,563	22,406	24,617
55 and Over	31,919	38,632	42,037	45,134	48,125
Total	179,326	203,167	215,324	228,676	258,693

Percent Change in Age Groups

Age Group	1960-1970	1970-1975	1975-1980	1980-1990
Under 20	11.4	(0.6)	1.6	15.1
20 - 24	51.6	18.5	8.6	(18.2)
25 - 34	9.1	24.9	18.8	13.0
35 - 44	(4.2)	(1.5)	11.7	45.4
45 - 54	12.5	1.6	(5.2)	9.9
55 and Over	21.0	8.8	7.4	6.6
Total	13.3	6.0	6.2	13.1

Source: U.S. Department of Commerce, Bureau of Census 1960-1970, Projections - 1975-1990--Series D.

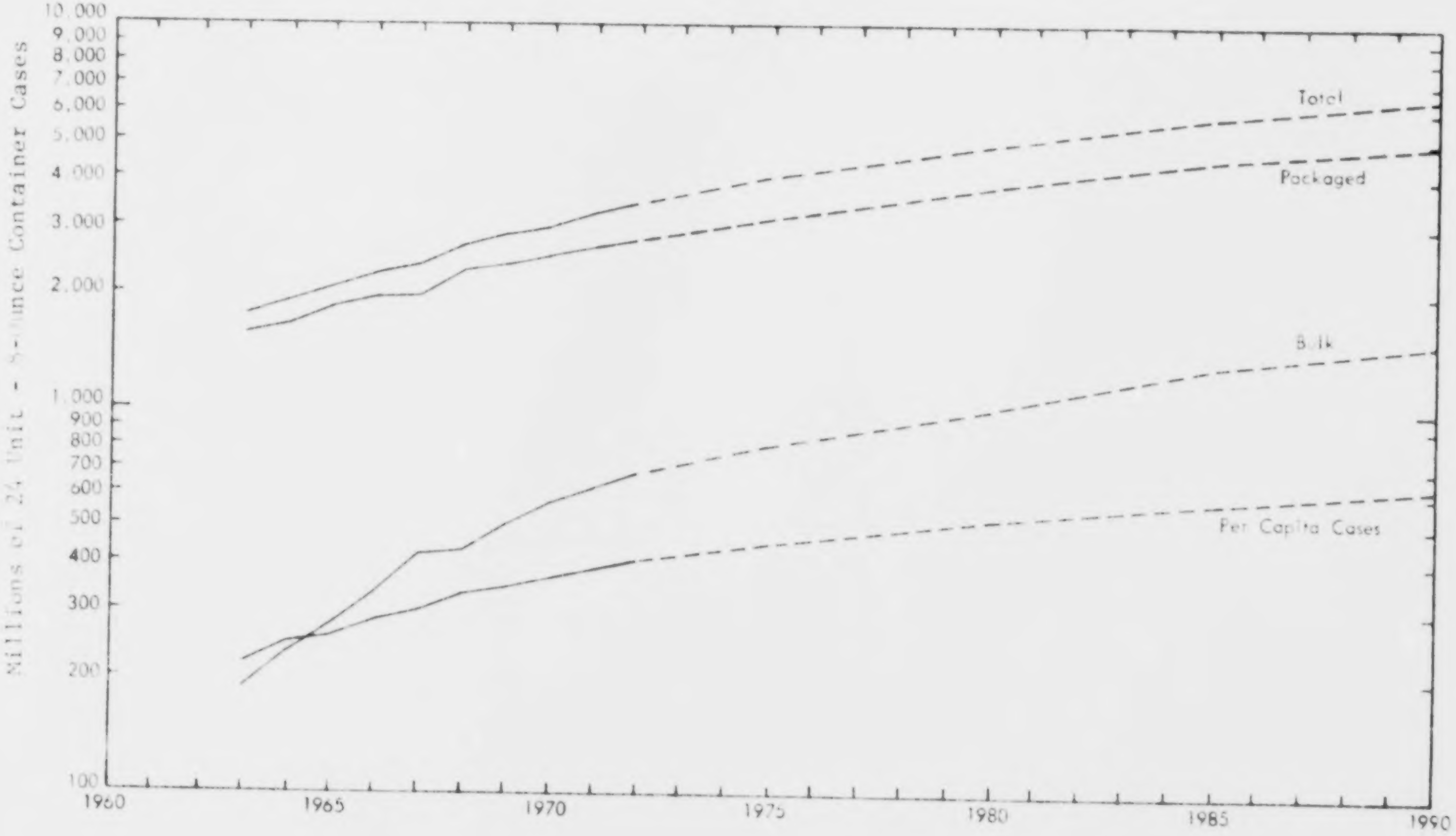

Figure A-1 - Soft Drink Shipments and Per Capita Consumption

There are two distinct segments of the soft drink industry commonly referred to as the "package" and "bulk" markets. Package markets include all soft drinks sold in metal cans and glass containers, while bulk includes premixed and postmixed soft drinks sold through vending machines and fountain dispensers where the concentrated syrup is mixed and carbonated at the time of use. The package market is the chief outlet for soft drinks. However, the bulk market has grown at a faster rate (although from a much smaller base). Table A-4 and Figure A-1 show the historical and projected demand for packaged and bulk soft drinks. Bulk soft drinks increased from slightly over 1 percent of the market in 1963 to 19.4 percent in 1972. They will continue to increase their share of this market, but at a slower rate, reaching a 21 percent share by 1980 and 22.4 percent by 1990. Thus, the package market will grow at slightly less than the overall soft drink market. Demand at 2.85 billion equivalent cases in 1972 will increase at a rate of 4.8 percent per year through 1975; at 3.9 percent from 1975 to 1980 when it will reach a volume of 3.96 billion cases. The more rapid growth of the bulk market will be a result of the increasing trend of eating out and the popularity of vending machines in commercial and industrial establishments.

TABLE A-4

ANNUAL CONSUMPTION OF SOFT DRINKS
BY MARKET SEGMENT, 1960 TO 1990
(Thousands of 192-ounce cases)

Year	Total	Packaged	Bulk	Per Capita 8-oz Containers
1960	1,476,544	N/A	N/A	192
1961	1,524,236	N/A	N/A	198
1962	1,667,514	N/A	N/A	213
1963	1,800,915	1,615,000	186,000	227
1964	1,948,590	1,715,000	234,000	243
1965	2,104,282	1,933,000	271,000	259
1966	2,352,587	2,023,000	330,000	287
1967	2,470,452	2,043,000	427,000	298
1968	2,777,035	2,347,000	430,000	331
1969	2,913,110	2,409,000	504,000	344
1970	3,096,635	2,521,000	575,000	362
1971	3,353,615	2,716,000	637,000	388
1972	3,541,417	2,850,000	690,000	406
1975	4,100,000	3,280,000	820,000	457
1980	5,020,000	3,960,000	1,060,000	527
1985	5,940,000	4,640,000	1,300,000	584
1990	6,860,000	5,320,000	1,540,000	636

Source: National Soft Drink Association 1960-1972, MRI estimates 1972-1990.

Soft Drink Containers: The bottler, and subsequently, the consumer, has a wide choice of sizes and types of containers. Originally, most soft drinks were packaged in returnable glass containers. The sizes were small, ranging from 6- to 10-fluid ounces volume. The consumer paid a deposit on the container and returned it for redemption of his deposit. The empty bottles were returned to the bottler who washed and reused them from 15 to 20 or more times before they were lost, broken or discarded. After World War II, the nonreturnable glass container and the metal can were introduced as commercial packages, but grew slowly until the 1960's when they became popular with consumers; the soft drink packages used marketing concepts based on "convenience" and "easy disposability" of one-trip containers.

Returnable bottles, which accounted for 92 percent of the volume as recently as 1963, began to lose their share of the market. By 1972, returnable bottles represented only 38.5 percent of the volume of packaged soft drinks. Metal cans increased during the same period from 6 percent to 34 percent, and one-way bottles from 2 percent to 27.5 percent (Figure A-2).* Because of the rapid growth of packaged soft drinks, the total volume packaged in returnable bottles did not begin declining until 1966.

Metal cans will continue to increase their share of the packaged market through 1980, when they reach 41.6 percent of the 3.96 billion cases consumed. During this same period, the one-way glass container will increase its share to 29.3 percent and the returnable container will continue its decline to a 29.1 percent share. With the introduction of the plastic container by 1980, metal and glass containers will have their respective market shares reduced. By 1990, metal cans will be 41 percent; one-way glass, 23.6 percent; returnable glass, 23.2 percent; and plastic bottles, 12.2 percent (Figure A-3).

Since the volume of soft drink consumption will be increasing during this period, the total of equivalent cases for each of the containers with the exception of returnable glass will continue to increase. The absolute decline in value packaged in round-trip containers will end by 1975 and increase slightly through 1990 (Figure A-4).

Container Selections: The choice of containers available in the future will be affected by a number of recent developments. The major factor has been the acceptance of the large resealable glass container. These containers are being made available in 24-, 32-, 48- and 64-ounce sizes and are estimated to have captured 14.6 percent of the 1973 market for packaged drinks, from only 4.7 percent in 1965. Projections indicate that they could reach 23.6 percent of the 1975 market.91/

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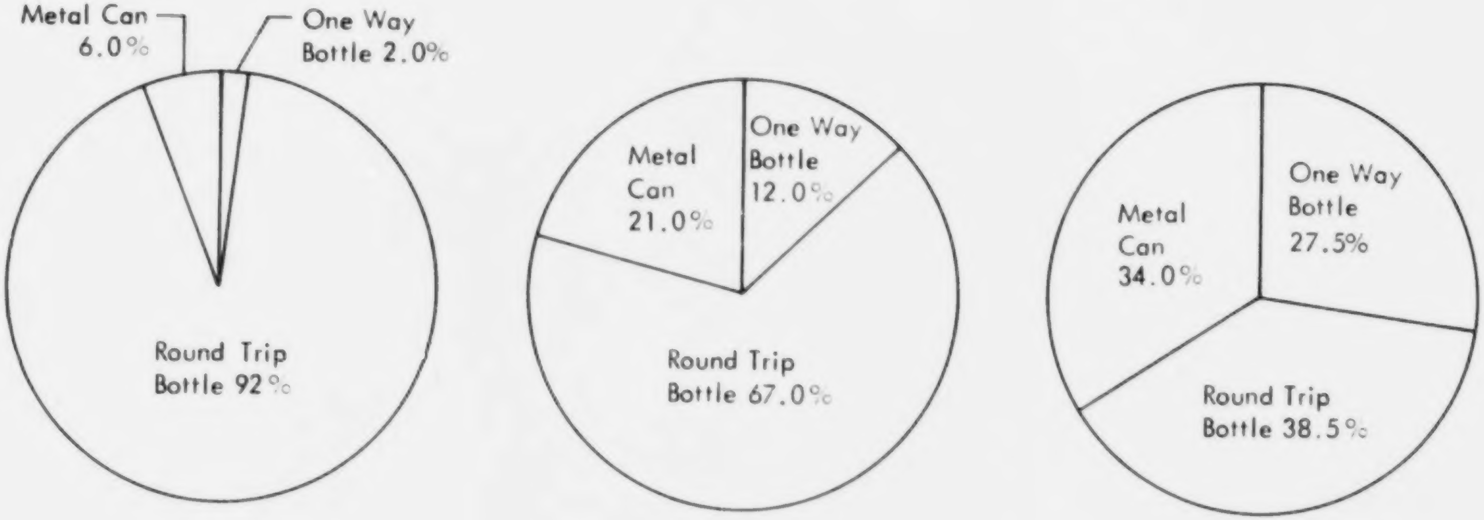
* Data given in this section is on the basis of equivalent 8-ounce containers which is not the same as the actual as-packaged container profile. Thus, this data does not correspond directly to Table A-5 presented later.



1963
1,615,000,000 Cases a/

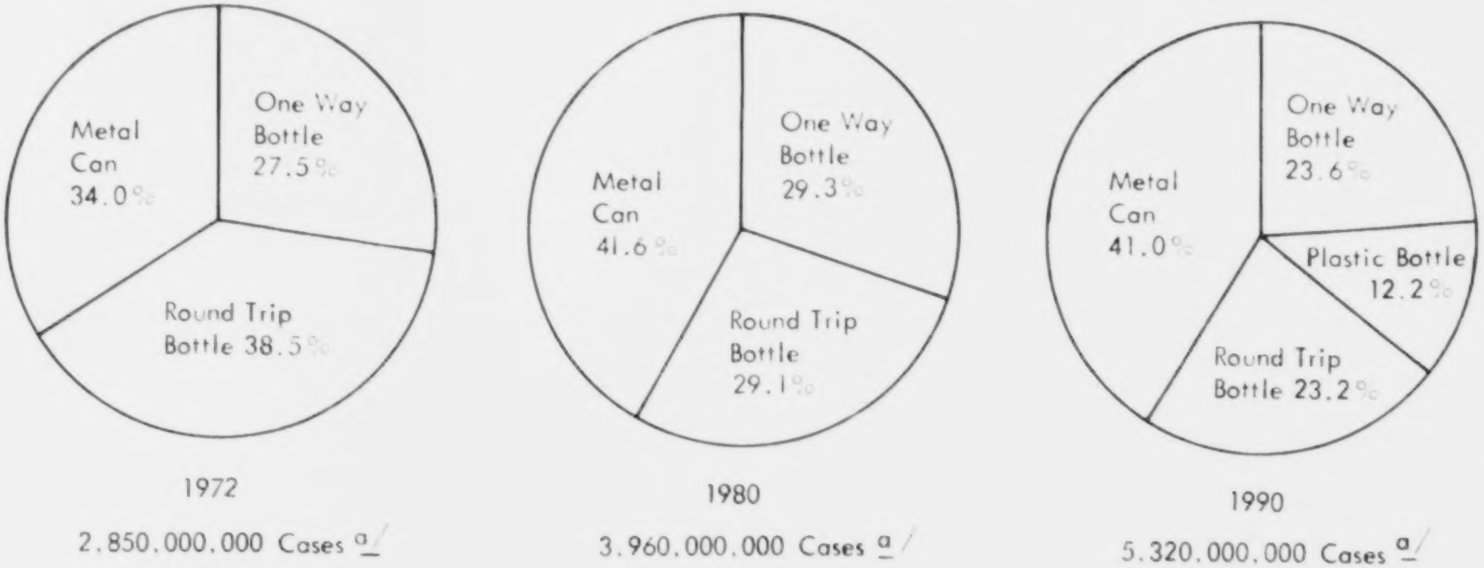
1967
2,043,000,000 Cases a/

1972
2,850,000,000 Cases a/

a/ Based on equivalent 8-ounce containers, not on an as-packaged basis.

SOURCE: Glass Container Manufacturers Institue

Figure A-2 - Soft Drink Packaging Market Share, by Container, 1963-1972



1972

2.850.000.000 Cases a/

1980

3.960.000.000 Cases a/

1990

5.320.000.000 Cases a/

a/ Based on equivalent 8-ounce containers, not on an as-packaged basis.

SOURCE: MRI Estimates

Figure A-3 - Soft Drink Packaging Market Share, by Container, 1972-1990

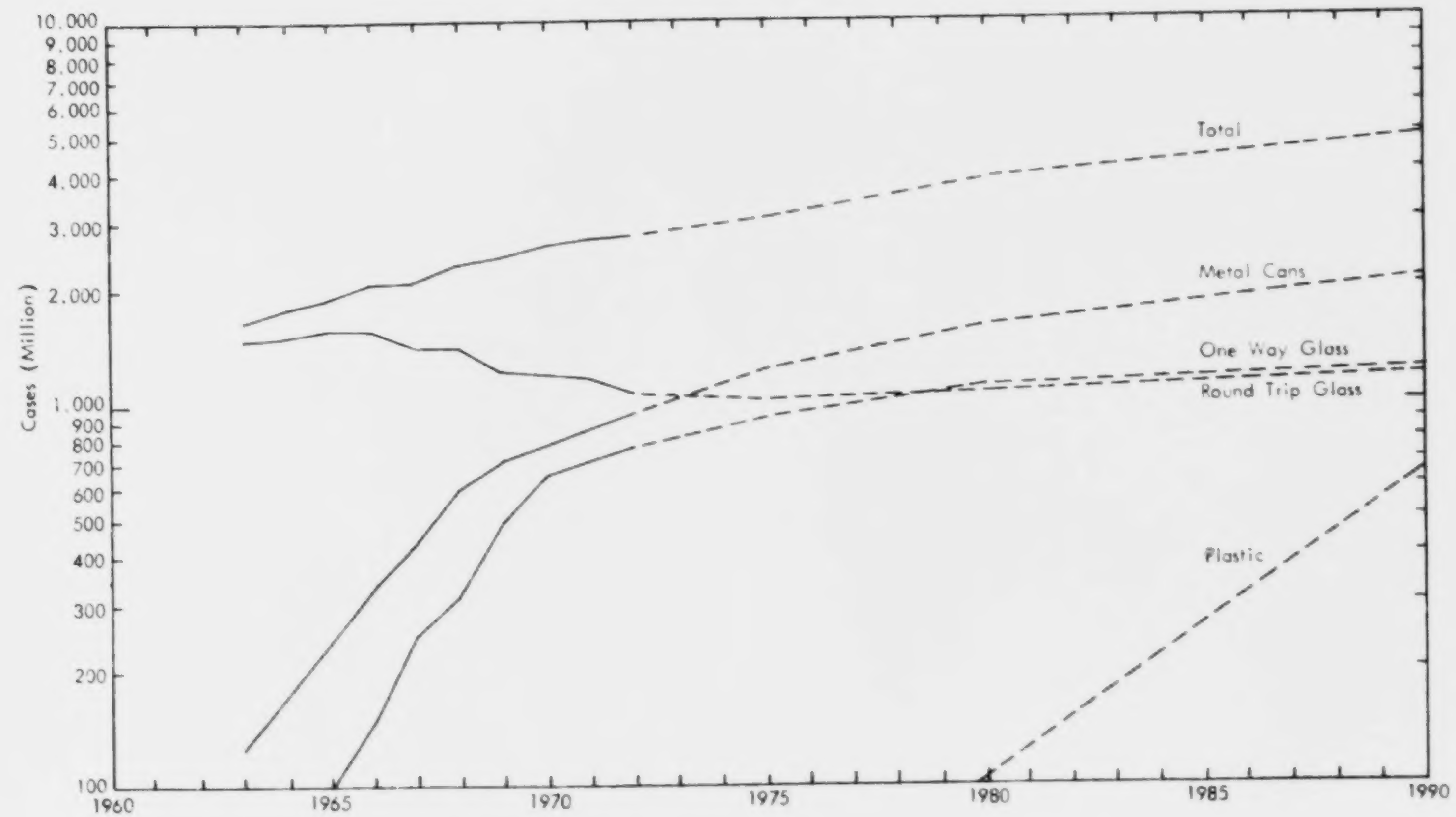


Figure A-4 - Soft Drink Consumption, By Container, 1963-1990
(Millions of 24-8-Ounce Cases)

This development has eliminated a large segment of the "take home" market from the metal can which is not available in sizes greater than 16 ounces. The resealable closure feature, combined with the economics of the larger sizes, has made glass the desired container for larger sizes.

The 12-ounce can is the predominant metal container with a small share in 16-ounce sizes. It has been reported that a 32-ounce resealable can is being tested. However, the present state of technology and economics do not indicate that it will be commercial within this decade. Cans will be the chief container in markets where the beverage will be consumed immediately after opening.

A second development has been the plastic coated and laminated glass containers which are designed to reduce breakage and weight. Owens-Illinois has introduced "Plasti-Shield," a nonreturnable glass container with a jacket of foamed polystyrene around the exterior of the bottle. It not only reduces breakage, but allows the use of a lighter weight container. A quart Plasti-Shield container weighs 14.5 ounces compared to 21.5 ounces for a standard nonreturnable.[92]

Other glass container manufacturers are developing more resistant glasses. Thatcher has "Shatter Guard," which is a glass container with a tight fitting outer envelope of a proprietary plastic copolymer that offers improved safety and a 21 percent reduction in weight. Indian Head, Anchor Hocking and Brockway Glass have also developed or are marketing similar containers.[16]

It is the opinion of many experts within the industry that these containers are an interim step to the development of the all-plastic blow molded containers, and that plastic-coated containers will reach no more than 10 percent of the market. We believe this to be a reasonable estimate.

The third development which is receiving wide interest is the all-plastic container. Until the recent availability of nitrile resins, there were no commercial plastics that were clear, nearly impermeable to moisture, oxygen and carbon dioxide transmission, and had the desired strength to permit molding into a soft drink container. Vistron Division of Sohio began exploring high nitrile polymers in the mid 1960's and undertook their commercial development. Other firms announced similar developments, so that today there are numerous "barrier" resins being test marketed for soft drinks. Others besides Vistron's "Barex" include Monsanto's "Lopac," and E. I. DuPont's MR-16. Both Barex and Lopac soft drink containers have been tested in selected markets and have received good acceptance by the consumer.[93]

Although the barrier resins have been tested and found to be desirable to the consumer, there is no commercial use of plastic soft drink containers today, even though they are being test marketed extensively.* The major limitation is the cost to the bottler. At the present price level, plastic does not provide enough advantage in lighter weight and transportation savings to be used in significant volumes. The amount of resin in the container can be reduced only so far with current technology before "creep" or expansion of the container is experienced and it is at the minimun level today. Since the resins are relatively new and plastics have historically declined in price as volume increases, future prices should make them more competitive with glass containers. We anticipate that these containers will begin to appear commercially in 1975, but not become significant before 1980. By 1990, we anticipate 5 billion plastic containers will be used in soft drink packaging.

There is also a possibility that composite resins which are in the early stages of development could become competitive with nitrile resins in the next decade. Several resin manufacturers are exploring this route to the development of a soft drink container.

Metal Cans: The metal can, although in use for many years, did not seriously challenge the glass container until the 1960's when franchised bottlers began to install canning lines to compete with contract canners (who package "private label" soft drinks for the large supermarket chains). The development of the easy-open aluminum top also stimulated consumer demand for the can.

As recently as 1956, only 300 million cans were being used to package soft drinks and accounted for about 1 percent of all packaged soft drinks. By 1963, over 2 billion cans were used, and by 1972, demand had grown to 15.6 billion units (Table A-5). Growth since 1968 has averaged 16.5 percent per year, but has been slowing since 1970.

Metal cans will continue to increase their share of the package market although at a slower rate. Growth to 1975 will be at 7.2 percent per year when volume will be 19.2 billion units. Beyond 1975, growth will be at 5.1 percent per year, reaching a level of 24.6 billion cans in 1980 equivalent to 42 percent of the soft drink market. By 1990,30 billion cans will be used as growth slows to 2.3 percent per year.

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* Coca-Cola authorized use of Monsanto's Lopac beginning January 1974.

TABLE A-5

SOFT DRINK CONTAINER SHIPMENTS, 1960 TO 1990

(Billions of containers)

Year	Metal Cans[a]	One-way Bottles[b]	Round Trip Bottles[c] (Total Fillings)	Total	Returnable[b] Bottles Shipped
1960	0.81	0.25	--	--	1.41
1961	1.23	0.40	--	--	1.34
1962	1.65	0.48	--	--	1.57
1963	2.05	0.56	29.63	32.24	1.77
1964	2.80	0.63	30.95	34.38	1.91
1965	3.84	1.01	32.91	37.76	1.91
1966	5.63	1.98	30.46	38.07	1.92
1967	7.30	3.59	29.15	40.04	1.91
1968	10.03	4.64	26.46	41.13	1.75
1969	11.76	6.45	24.58	42.79	1.64
1970	13.10	8.34	23.56	45.00	1.72
1971	14.11	8.34	24.85	47.30	1.38
1972	15.60	8.76	23.83	48.19	1.45
1975	19.20	9.93	20.6	49.73	1.30
1980	24.60	11.23	18.0	53.83	1.30
1985	27.50	11.15	18.0	56.65	1.30
1990	30.00	11.00	18.0	62.00	1.30

Source: a/ Can Manufactures Institute 1960-1971, MRI estimates 1972-1990.
b/ U.S. Department of Commerce 1960-1971. MRI estimates 1972-1990.
c/ U.S. Department of Commerce, "Closures for Containers," 1960-1971; Midwest Research Institute estimates, 1972-1990.

There has not been noticeable trend away from the standard 12-ounce container which has been the most popular unit and should continue to be the preferred size because the contents can usually be consumed before losing carbonation. Sixteen-ounce cans are the only other significant size available to consumers and represents only a small portion of the market. It is projected to increase slowly at the expense of the 12-ounce container during the next decade. Unless a resealable container is developed, cans will be limited to the 16-ounce and under sizes.

Glass Containers: The market for glass containers is shared by the returnable and nonreturnable units. The returnable container is still the predominant unit with 23.8 billion filled in 1972. Since this container is reused on average 10 to 15* times, the actual production represents only replacement bottles and initial sales of introductory sizes. Actual shipments in 1972 amounted to 1.44 billion containers.

The popularity of the metal can and the nonreturnable glass container have eroded the demand for returnable containers. Shipments increased each year until 1966, when 1.92 billion units were produced and 30.46 billion were filled. Since then, both the replacement and the total fills have declined.

Most of the growth of the one-way glass container occurred between 1965 and 1970, when shipments rose from 1.01 billion units to 8.34 billion units. Growth in the past 3 years has been modest, reaching 8.76 billion in 1972.

This rapid growth followed by the sudden slowdown is in part a result of the changing average size of the containers. The one-way bottles were initially introduced as large containers. As they achieved greater acceptance from consumers, the smaller sizes were introduced and the average volume per container declined from 18.8 ounces in 1964 to 14.1 ounces in 1967. With the introduction of the larger 16- and 32-ounce nonreturnable containers, the average volume has again increased, reaching a level of 17.35 ounces in 1972. The trend to larger average size is projected to continue, reaching 18.5 ounces in 1975 and 20 ounces in 1980.

The returnable container has remained the preferred unit for the 6- to 12-ounce vending machine markets. Its volume has been relatively constant during the past decade, varying from 8.9 to 10.6 ounces.20/ However, there has been a significant change in the size mix for nonvended sales.

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* The subject of average trippage is a matter of considerable debate. We could not determine the actual trippage being experienced today. It is probably at least 12 trips for soft drinks, but varies over the nation from 5 to 20 trips and above. However, these estimates are based on discussions, not documentation.

The percentage of 6- to 9-ounce containers has declined significantly in favor of the larger 16- and 32-ounce resealable returnable (Table A-6). Indications are that this trend will continue and the average volume per container is increasing in returnable containers.

TABLE A-6

MARKET SHARE BY CONTAINER SIZE FOR SOFT DRINKS, 1967 AND 1972

(In percent)

Container (ounces)	Percent	
	1967	1972
6-9	18.6	8.6
10-12[a]	60.9	58.4
16	15.2	20.4
24 and over	6.2	12.6
Total	100.0	100.0

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[a] Metal cans and glass containers. All others are predominantly glass.
Source: National Soft Drink Association.

The development of the resealable feature and the promotion of the returnable bottle as the "ecological" container should begin to slow the decline in returnable containers. Similarly, the possibility of deposits on nonreturnable units will cause conversion back to returnable bottles in some states. Although Oregon and Vermont are the only states that have enacted this kind of law, it is possible that other states will consider similar laws which would cause a conversion to returnable units.* As Table A-5 shows, we are projecting a slight decline in returnable beverage containers through 1975 to a level of 1.3 billion units per year. There will also be a slow down in the growth of the nonreturnable beverage containers from its previous rapid rate. Total demand should increase about 4.3 percent per year through 1975, to a level of 9.9 billion units, and then increase at 2-1/2 percent per year to 11.2 billion units in 1980. Beyond 1980, with the introduction of the all plastic container, the total demand for nonreturnable and returnable containers will remain at the 1980 level.

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* E.g., South Dakota.

Beer Containers

The brewing industry is one of the oldest in the United States, dating back to the early 17th Century. It was not until 1840, when lager beer was introduced, that the manufacture of malt beverages became a major industry in this country. The lager beer which is a light, mild beer was readily accepted by the American public as being more palatable than the heavier dark beers and is today the predominant beer produced in this country. Beer is marketed to consumers in glass containers and metal cans or as draught in kegs and barrels. The latter is predominantly consumed in taverns and other establishments where beer is permitted to be served. Draught beer has declined from 48.3 percent of the total production in 1940 to 13.3 percent in 1972.

The total fillings of packaged beer (cans and bottles) was 23.2 billion units in 1962, and rose to 37.4 billion units in 1972. By 1990, the total packaged fillings of beer will be 62 million units.

In contrast to soft drinks, which are packaged by franchise dealers, beer is packaged at the brewery in much larger volume than corresponding soft drink plants. These plants continue to get larger as the brewing industry becomes more concentrated. The number of breweries has declined from 611 in 1940, to 158 in 1969.[94]

Beer Consumption: The growth rate of beer consumption has been erratic throughout its history in the United States. After increasing steadily during the early part of the century, consumption dropped rapidly with the advent of prohibition. When this law was repealed, production did not reach the preprohibition level until the Second World War. Demand increased from 55 million barrels in 1941, to 85 million barrels in 1946, and it remained at this level until the early 1960's. Growth again resumed, and demand from 1962 to 1972 increased at a rate of 3.7 percent per year. It has expanded more rapidly in recent years, growing at 4.3 percent per year between 1967 and 1972, when demand reached 131.9 million barrels (Table A-7).

TABLE A-7

BEER CONSUMPTION, 1962-1990
(In million barrels)

Year	Total Consumption	Packaged Barrels	Packaged Percent	Draught Barrels	Draught Percent
1962	91.2	74.1	81.3	17.1	18.7
1963	93.8	76.3	81.4	17.5	18.6
1964	98.6	80.7	81.8	17.9	18.2
1965	100.4	82.6	82.3	17.8	17.7
1966	104.3	86.5	83.0	17.8	17.0
1967	106.9	89.6	83.7	17.3	16.3
1968	111.4	94.0	84.4	17.4	15.6
1969	116.3	99.0	85.1	17.3	14.9
1970	121.6	104.4	85.9	17.2	14.1
1971	127.4	109.9	86.4	17.5	13.6
1972	131.9	114.2	86.7	17.7	13.3
1975	148.3	130.3	87.8	18.0	12.2
1980	178.4	159.4	89.3	19.0	10.7
1985	204.8	184.8	90.2	20.0	9.8
1990	226.2	205.2	90.7	21.0	9.3

Growth Percent/Year	Total	Packaged	Draught
1962-1967	3.2	3.9	0.2
1967-1972	4.3	5.1	0.4
1972-1975	4.0	4.5	0.5
1975-1980	3.6	4.1	1.1
1980-1990	2.4	2.5	1.0

Source: U.S. Brewers Association, 1962-1972; MRI estimate, 1972-1990.

Studies have shown that the highest percentage of beer drinkers are found among people under age 30 and the highest per capita volume intake of beer occurs among those age 30 to 44.[95] Table A-8 shows the present and projected population growth by age segment for the years 20 to 44 from 1960 to 1990. The large number of babies born after World War II became young adults of beer drinking age during the middle 1960's and caused the resurgent growth in beer consumption. This population group will continue to increase faster than the total population through 1980, and then slow between 1980 and 1990. Assuming that past trends will continue and that this group will be the greatest per capita consumers of beer, we project demand to grow at 4 percent per year through 1977, and then grow at a decreasing rate through 1990. Total consumption of beer which amounted to 131.9 million barrels in 1972, should rise to 178.4 million barrels in 1980 and 226.2 million barrels by 1990 (Table A-7). Packaged beer will parallel this growth, increasing from 114.2 million barrels in 1972 to 159.4 million barrels in 1980, and 205.2 million barrels in 1990 (Figure A-5). Draught beer, which has not grown in the past decade, will increase slightly during the period of this forecast.

Beer Containers: Originally, beer was packaged only in returnable glass containers, mainly in 12-ounce bottles. The metal can was introduced in 1935, and has demonstrated its popularity by becoming the largest volume container in the packaged beer market. Since 1962, metal cans have increased from 37.1 percent to 58 percent of all packaged beer (Table A-9, Figure A-6). Can volume during the same period increased from 9.1 billion to 21.6 billion units for a growth rate of 9.1 percent per year.

The nonreturnable glass container was introduced during the Second World War primarily for overseas shipment and was used to compete with the metal can for the "convenience" market after the war. Growth was slow, reaching only a 6 percent penetration of packaged sales by 1959. In that year, the glass container manufacturers redesigned the bottle and lowered its cost to compete with the can. This did much to stimulate the growth of the one-way glass container and it increased from 3.4 billion units and 14 percent of the packaged market in 1962, to 7.6 billion units and 24 percent of the packaged market in 1972. This is equivalent to a growth rate of 8.4 percent per year for the period; total beer demand since 1967 has increased at 5.8 percent per year.

TABLE A-8

U.S. POPULATION BY AGE

(Thousands)

Age Group	1960	1970	1975	1980	1990
20-24	10,803	16,372	19,404	21,067	17,823
25-34	22,823	24,909	31,114	36,962	41,791
35-44	24,072	23,072	22,721	25,370	36,902
Total	57,698	64,353	73,239	83,399	95,516

PERCENT CHANGE

Age Group	1960-1970	1970-1975	1975-1980	1980-1990
20-24	51.6	18.5	8.6	(18.2)
25-34	9.1	24.9	18.8	13.0
35-44	(4.2)	(1.5)	11.7	45.4
Total	11.5	13.8	13.9	14.5

Source: U.S. Department of Commerce, Bureau of Census, 1960-1970; Projections--1975-1990, Series D.

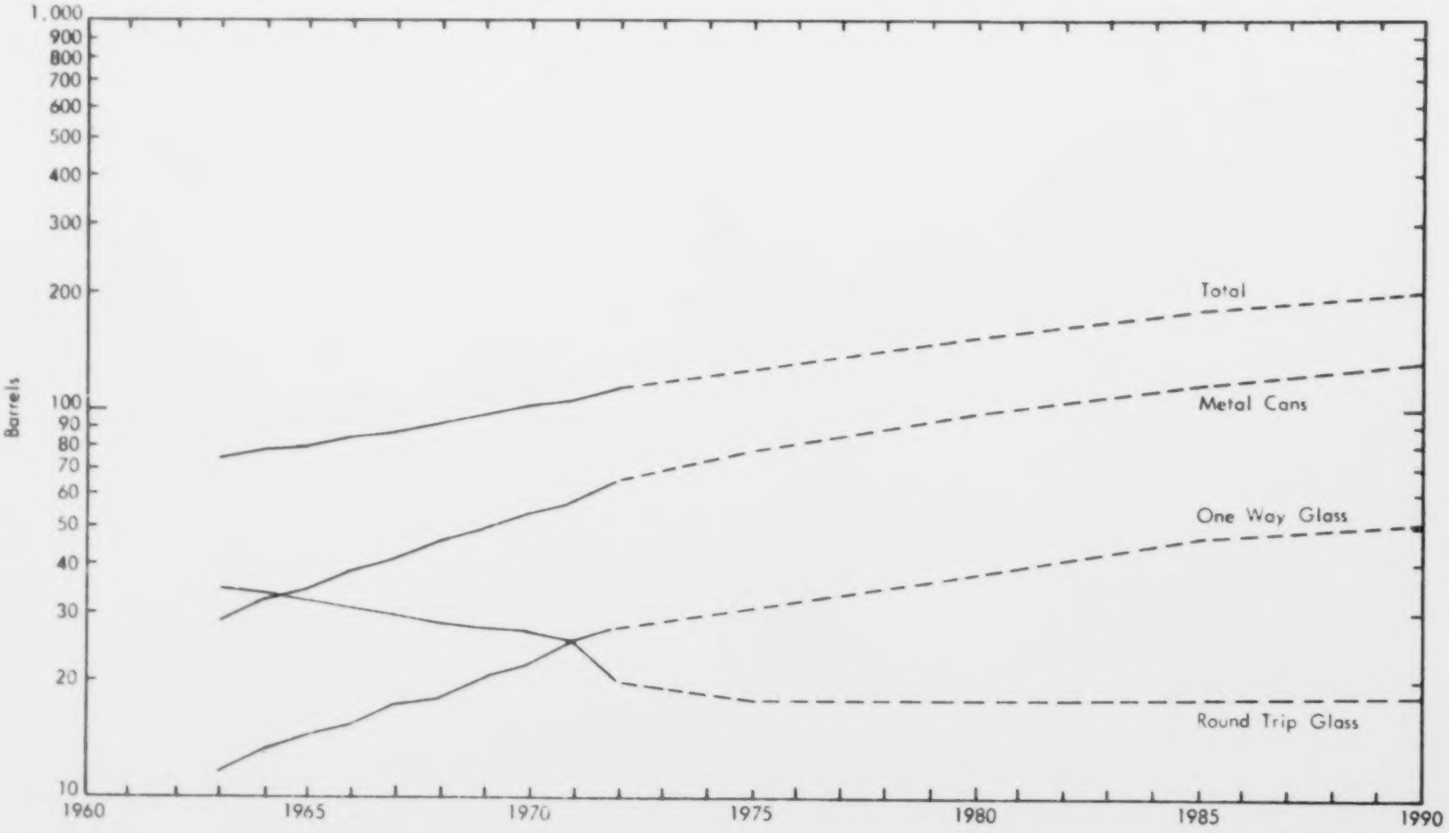


Figure A-5 - Beer Consumption By Container, 1963-1990
(Million Barrels)

TABLE A-9

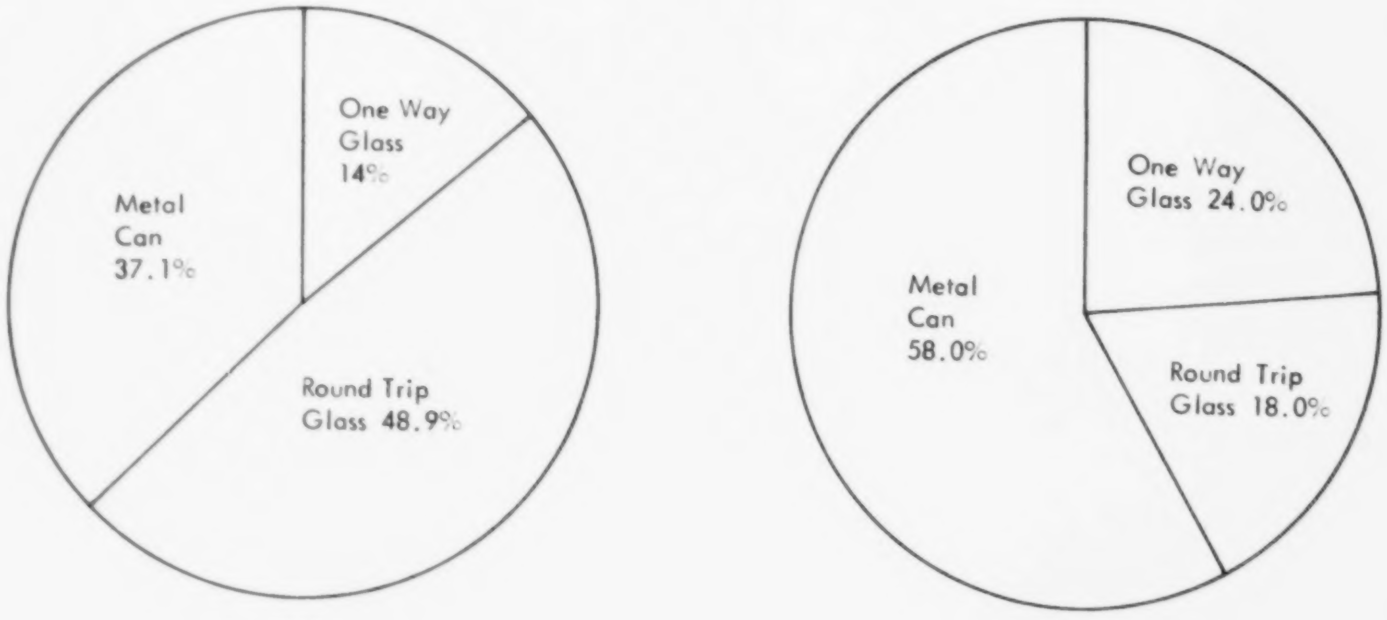
PACKAGED BEER CONSUMPTION BY PACKAGE TYPE, 1962-1990

(In million barrels)

Year	Total	Metal Cans		One-Way Glass		Round-Trip Glass	
		Barrels	Percent	Barrels	Percent	Barrels	Percent
1962	74.1	27.5	37.1	10.3	14.0	36.3	48.9
1963	76.3	29.6	38.8	11.7	15.3	35.0	45.9
1964	80.6	32.9	40.8	13.2	16.4	34.5	42.8
1965	82.6	34.5	41.7	14.2	17.2	33.9	41.1
1966	86.5	38.9	45.0	15.2	17.6	32.4	37.4
1967	89.5	41.6	46.5	17.5	19.5	30.4	34.0
1968	94.0	46.3	49.2	18.0	19.2	29.7	31.6
1969	99.0	50.4	51.0	20.8	21.0	27.8	28.0
1970	104.4	55.3	53.0	22.0	21.0	27.1	26.0
1971	109.9	58.7	53.4	25.8	23.5	25.4	23.1
1972	114.2	66.2	58.0	27.4	24.0	20.6	18.0
1975	130.3	80.3	61.6	31.8	24.4	18.2	14.0
1980	159.4	101.3	63.5	39.9	25.1	18.2	11.4
1985	194.8	119.0	64.5	47.6	25.6	18.2	9.9
1990	205.2	134.5	65.5	52.5	25.6	18.2	8.9

Growth Percent/Year	Total	Metal Cans	One-Way Glass	Round-trip Glass
1962-1967	3.2	8.6	11.2	(3.5)
1967-1972	4.3	9.8	9.4	(8.1)
1972-1975	4.0	6.7	5.9	(4.1)
1975-1980	3.6	4.7	4.6	0.0
1980-1990	2.4	3.1	2.8	0.0

Source: U.S. Brewers Association, 1962-1972. MRI estimate 1975-1990.



1962

74,100,000 Barrels

1972

114,200,000 Barrels

SOURCE: U.S. Brewers Association 1962 - 1972

Figure A-6 - Packaged Beer Container Market Shares, 1962-1972

The growth of the metal can and single trip glass container has been at the expense of the returnable bottle. Its share of the market has steadily declined from 48.9 percent in 1962, to 18 percent in 1972. Total bottles filled, which was estimated at 11.5 billion units in 1962, have declined to 8.3 billion in 1972. Because of the high trippage* on returnable beer bottles, the annual replacement production only amounted to 245 million containers in 1972, a decline from 353 million in 1962.

As contrasted to the soft drink container, there has been no noticeable change in size during the past decade. The 12-ounce container is the most popular unit in bottles and metal cans, and accounts for approximately 70 percent of the total packaged beer. There has been some increase in demand for the larger sizes such as the 32-ounce glass quart and the 16-ounce can and glass container, which accounts for most of the remaining 30 percent of the package market.

A small percentage is also available in 8-, 11-, and 15-ounce cans and bottles, but their volume is small. The plastic container, which is predicted to penetrate the soft drink market by 1980, is not expected to become a factor in the beer market. Beer must be pasteurized at 150°F and most barrier resins begin to soften at this temperature. There are some plastic containers under test by selected brewers, but we do not envision they will be a factor during this decade.

Metal cans are projected to continue to increase their share of the packaged beer market, although at a slower rate during the next 2 decades. From a share of 58 percent of the packaged beer market, cans will increase to 63.5 percent by 1980, and 65.5 percent by 1990 (Figure A-7). Since we do not project any increase in the average size of the can during this period, demand will reach 33.5 billion units in 1980, and 44.5 billion in 1990 (Figure A-8). This is equivalent to a growth of 5.6 percent per year through 1980, which will slow to 3.1 percent per year through 1990 (Table A-10).

Nonreturnable glass containers, which now account for 24 percent of the package market, will increase slowly to 25.1 percent by 1980, and 25.6 percent by 1990. The average size of these containers is projected to increase slowly as the trend to larger sizes continues because of the advantage of the resealable cap. Thus, the demand for 7.6 billion containers in 1972 will increase to 8.3 billion in 1975 and 9.1 billion by 1980. This is equivalent to a growth of 2.2 percent per year through 1980.

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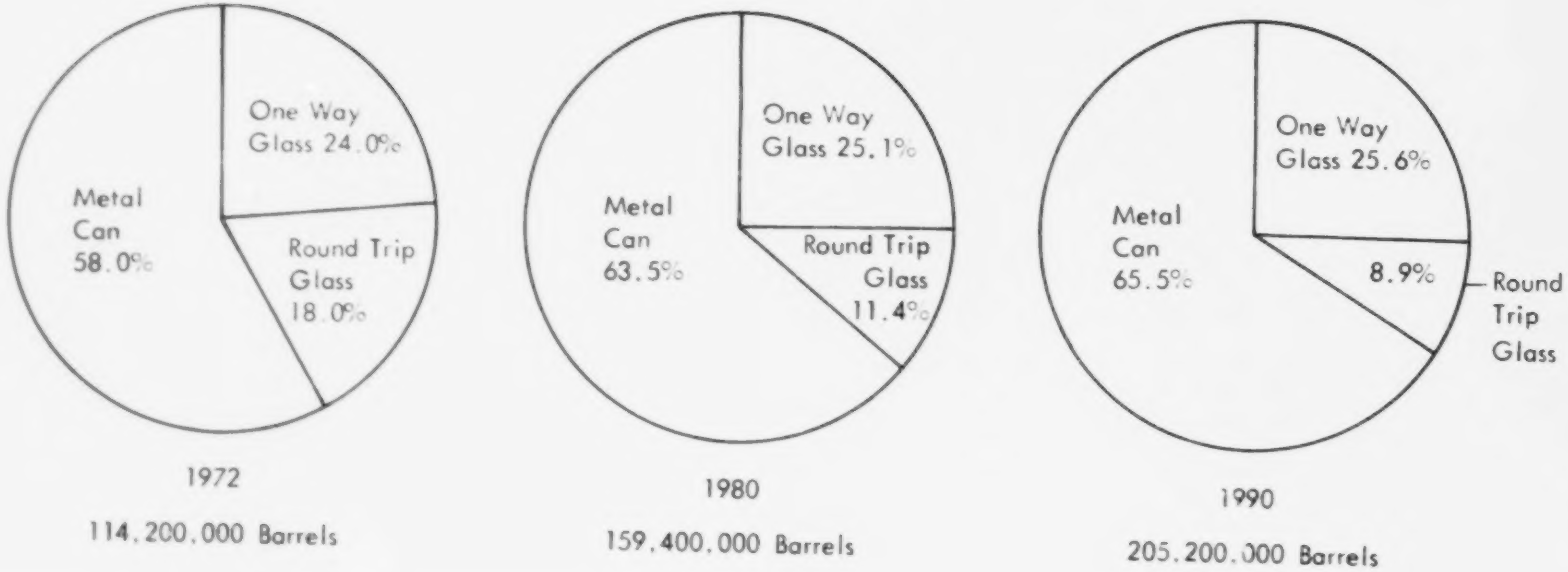
* We estimate average trippage of at least 18 trips for beer. However, we have no solid documentation and the average trippage is a combination of on-premise and carry-out beer containers.



SOURCE: U.S. Brewers Association 1972
MRI Estimates 1980; 1990

Figure A-7 - Packaged Beer Container Market Share, 1972-1990

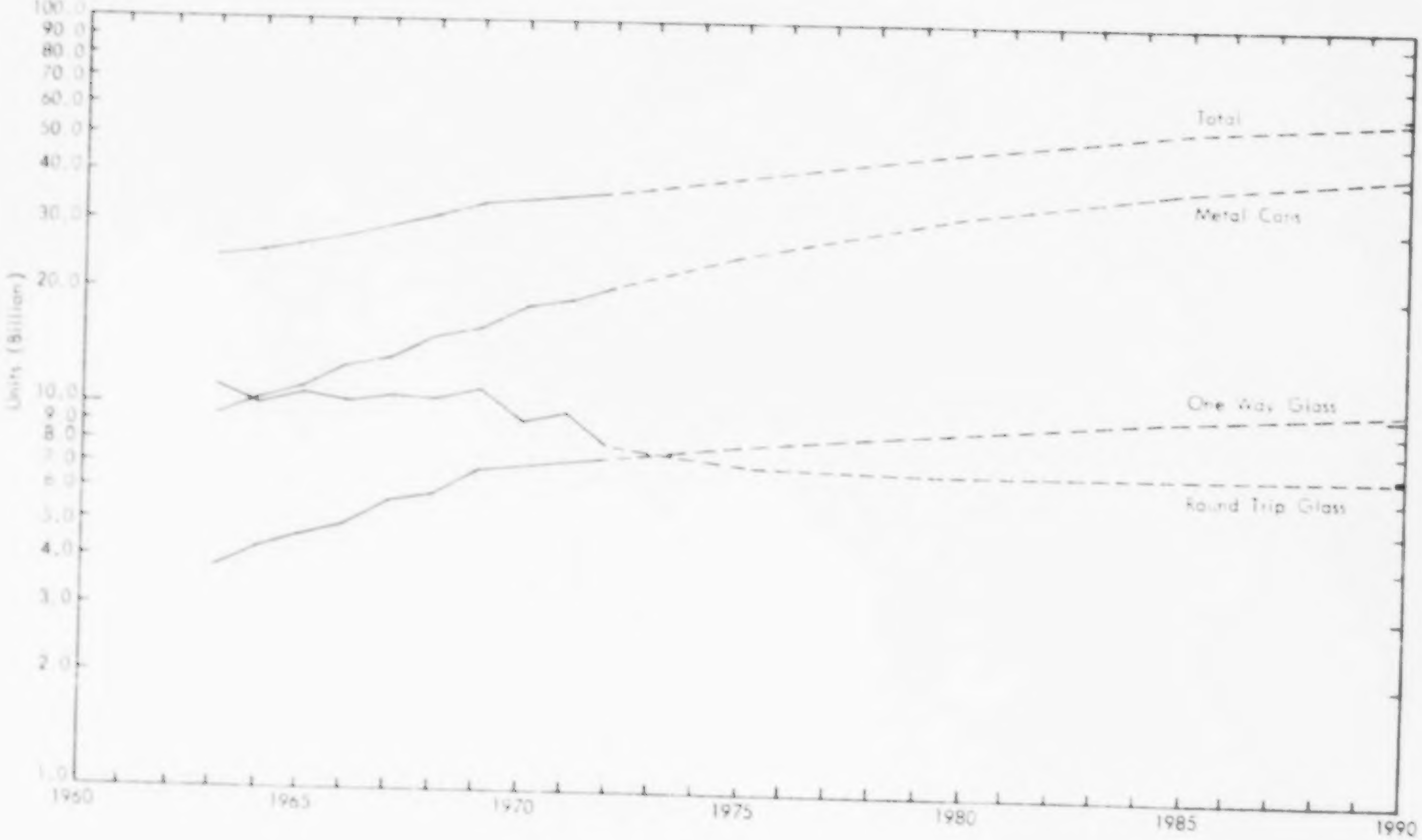


Figure A-8 - Beer Container Shipments, 1963-1990

TABLE A-10

BEER CONTAINER SHIPMENTS, 1962-1990
(Billions of containers)

Year	Metal Cans[a]	One-Way Glass[b]	Round-Trip Glass Total Fillings[c]	Total	Round-Trip Replacement Glass[b]
1962	9.1	3.4	10.9	23.4	0.35
1963	9.8	3.9	11.4	25.1	0.39
1964	10.9	4.4	10.7	26.0	0.42
1965	11.5	4.7	11.1	27.3	0.50
1966	13.0	5.0	10.8	28.8	0.58
1967	13.8	5.8	11.0	30.6	0.62
1968	15.3	6.0	10.9	32.2	0.48
1969	16.7	6.9	11.4	35.0	0.48
1970	19.0	7.2	9.6	35.8	0.34
1971	19.6	7.4	10.0	37.0	0.27
1972	21.5	7.6	8.3	37.4	0.25
1975	26.6	8.3	7.4	42.3	0.22
1980	33.5	9.1	7.1	49.7	0.22
1985	40.5	10.0	7.1	57.6	0.22
1990	44.5	10.5	7.1	62.1	0.22

Growth Percent/Year	Metal Cans	One-Way Glass	Round Trip Replacement
1962-1972	9.0	8.4	(3.4)
1967-1972	9.2	5.8	(19.9)
1972-1980	5.6	2.2	1.7
1980-1990	3.1	1.5	0.0

Sources: a/ Can Manufacturers Institute, 1962-1972; MRI estimates, 1972-1990.
b/ U.S. Department of Commerce, 1962-1972; MRI estimates, 1972-1990.
c/ U.S. Department of Commerce, "Closures for containers," 1962-1971; Midwest Research Institute estimates, 1972-1990.

Round-trip glass containers should continue to decline through 1990, at which point they are projected to stabilize at about 7.1 billion fills per year. Total production of round-trip glass containers for replacement, which was 245 million units in 1972, should decline to 216 million units by 1975, and remain at that level through 1990.

Distilled Spirits Containers

Distilled spirits are an important segment of the beverage market. Products classed as distilled spirits include whiskey, gin, vodka, rum, brandy, cordials and liqueurs. Consumption of these products amounted to 389 million wine gallons* in 1972, and has grown at a rate of 4.3 percent per year during the past decade.

Bourbon and blended whiskey are the largest selling distilled spirits, accounting for 37.5 percent of the 1972 market. Demand for these products has been static during the last decade due to the consumers' increasing demand for imported Scotch and Canadian whiskeys which now amount to 23.1 percent of the market. Rising disposable income, increased leisure time and the increased percentage of population in the 25 to 35 age bracket have been stimulants to the growth in demand for distilled spirits. These factors will generate a 4.5 percent per year growth in demand during the rest of the decade, to a level of 550 million gallons by 1980 (Table A-11). Per capita consumption will increase from 1.86 gallons in 1972, to 2.40 gallons in [illegible].

Sales of distilled spirits are strictly controlled by the federal government. Shipments are nearly all in glass containers which vary in size from less than 1/2 pint to as large as 1 gallon. The most popular sizes are the 4/5-quart and quart containers. Shipments by container size are shown in Table A-12 for the years 1961, 1966 and 1971. There has been a trend toward the quart and half-gallon containers which have had the greatest growth during the past decade. Containers holding a quart or greater have increased their market share from 24.5 percent of the volume in 1961 to 44 percent in 1971. The trend toward the larger sizes should continue as the per capita consumption of distilled spirits increases. Table A-13 shows the number of containers by size during the same period. Total container shipments increased from 1.677 billion in 1961 to 2.298 billion in 1972. Because of increasing container size, the number of containers grew at a rate of 3.3 percent per year during this period which is less than the 4.3 percent volume growth. Assuming that this trend toward larger sizes will continue at the same rate, the growth for containers is projected at 3.5 percent per year through 1980, when they will reach a level of 3.16 billion units.

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* Wine gallon is a term used by the Alcohol, Tobacco and Firearms Division, Internal Revenue Service, U.S. Treasury Department, for measurement of distilled spirits volume. It is equivalent to (1) U.S. gallon (231 cubic inches).

TABLE A-11

DISTILLED SPIRITS CONSUMPTION, 1960 TO 1980

Year	Equivalent Wine Gallons (millions)	Consumption Per Capita	Glass Containers (billions)
1960	234.7	1.31	--
1961	241.5	1.32	1.68
1962	253.7	1.37	1.72
1963	259.0	1.37	1.78
1964	275.9	1.44	1.86
1965	293.0	1.52	1.96
1966	307.8	1.58	2.08
1967	323.5	1.64	2.16
1968	344.1	1.73	2.27
1969	361.7	1.80	2.42
1970	371.1	1.82	2.42
1971	381.1	1.85	2.30
1972	389.0	1.86	2.40
1975	444.0	2.06	2.66
1980	550.0	2.40	3.16
1985	650.0	2.70	3.50
1990	770.0	3.00	4.00

Growth - Percent Per Year

	Gallons	Containers
1961-1972	4.3	3.3
1972-1980	4.5	3.5
1980-1990	3.5	2.5

Source: Distilled Spirits Institute, 1960-1972; MRI estimate, 1972-1980.

TABLE A-12

DISTILLED SPIRITS VOLUME BY CONTAINER SIZE, 1961 TO 1971
(In thousand wine gallons equivalent)

Size Container	1961	1966	1971	Percent Increase 1961-1971
1/2 Pint	30,033	36,325	38,032	26.6
3/4-1 Pint	43,119	48,770	47,507	10.2
3/4-4/5 Quart	104,062	121,923	120,219	15.5
1 Quart	56,628	91,050	126,275	123.0
1/2 Gallon	2,713	10,127	35,363	1,203.0
1 Gallon	103	245	481	367.0
Total	242,548	308,440	367,879	51.5

Source: Distilled Spirits Industry.

TABLE A-13

DISTILLED SPIRITS CONTAINER DEMAND BY SIZE, 1961 TO 1971
(In thousand units)

Size Container	1961	1966	1971	Increase 1961-1971
1/2 Pint	547,171	682,497	721,836	174,665
3/4-1 Pint	352,985	405,564	398,038	45,053
3/4-4/5 Quart	544,908	610,376	602,396	47,488
1 Quart	226,512	364,202	505,104	278,592
1/2 Gallon	5,427	20,254	70,726	65,299
1 Gallon	103	245	481	378
Total	1,677,106	2,083,138	2,298,581	621,475

Source: Distilled Spirits Industry.

Imported distilled spirits are mostly Scotch and Canadian whiskey. Their share of the market during 1971 represented 26.2 percent of the total consumption--an increase from 16.5 percent in 1962. About 70 percent of these spirits are imported in bottles, although increasing quantities of bulk Scotch and Canadian whiskeys are being bottled in the United States. Bottled imported spirits amounted to 13.3 percent of all bottled shipments in 1961, and increased to 17.6 percent in 1971. The trend toward bulk imports should continue and foreign bottled spirits will level off at about 20 percent of the market by 1980.

Although glass has been the sole container for this market, PVC bottles have been test marketed for replacement of the larger container sizes. Until this year, it was expected that these bottles would be approved and that they would be accepted in the larger container sizes. Recent tests indicated to the FDA that the alcohol was reacting with the resin in the container, and FDA has suspended the use of these bottles until further testing and evaluation is conducted. It is impossible to determine, at this time, whether they will eventually be approved; therefore, we are assuming that glass will remain the sole container until improved resins are developed for this market. These resins will most likely be the nitrile or composites and will not be commercial before 1980. Beyond 1980, we have assumed that the plastic container will be accepted and absorb all the growth in this market. Glass containers will increase to 3.0 billion units by 1980, and remain at this level (Figure A-9).

Wine Containers

Wine is a product of fermented juice of grapes or other fruit. It may include the addition of sugar, grape concentrate, herbs or alcohol. Wines are usually classified into table wine, dessert wine, vermouth, sparkling wines and "pop wine." The latter are lightly carbonated wines which are heavily advertised to the youth segment of the market. Table wine is the most popular brand with dessert wine a distant second. The pop wines have had the fastest growth, increasing from 16.1 million gallons in 1970, to 46.3 million gallons in 1972 (Table A-14).

Prior to 1966, wine grew steadily at 2 to 3 percent per year. The increasingly affluent American public suddenly became aware of wine as a table drink and demand increased at over 10 percent per year to a volume of 337 million gallons in 1972. This rate of growth is not expected to be maintained since the supply is limited by the amount of grapes harvested. Demand will grow at a more moderate rate of 4.6 percent per year through 1980 to 485 million gallons (Table A-15).

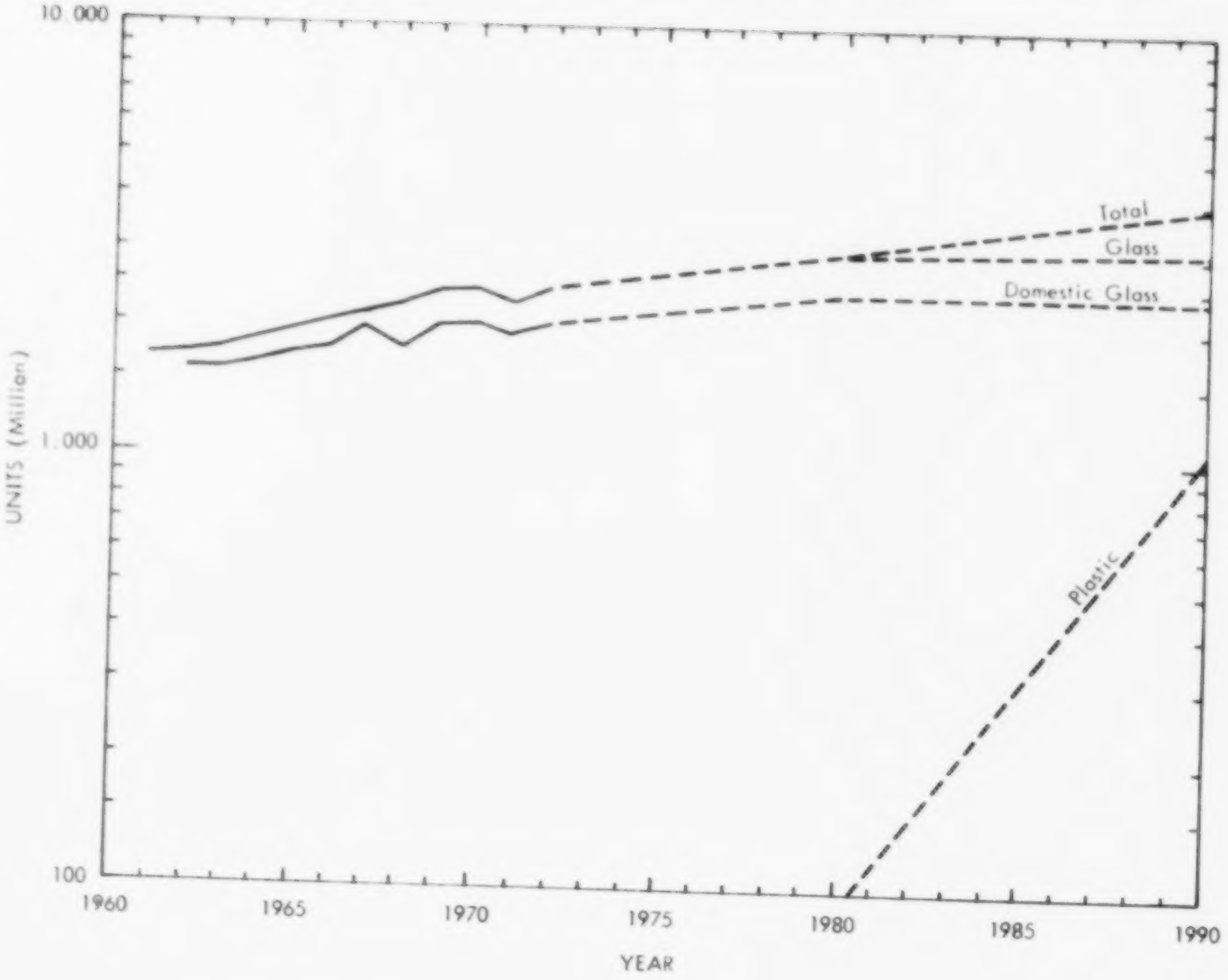

Figure A-9 - Distilled Spirits Consumption by Container, 1961-1990

TABLE A-14

WINE DEMAND BY TYPE, 1970 TO 1972

(In million wine gallons)

Type Wine	1970 Production	1970 Import	1970 Total	1971 Production	1971 Import	1971 Total	1972 Production	1972 Import	1972 Total
Table Wine	112.7	20.7	133.4	130.1	26.0	156.2	136.3	37.5	173.8
Dessert Wine	71.3	2.4	73.7	71.0	2.9	73.9	70.0	2.7	72.7
Vermouth	5.1	5.1	10.2	4.9	5.4	10.3	5.1	4.9	10.1
Other still wine									
Less than 14%	16.1	--	16.1	29.3	--	29.3	46.3	--	46.3
More than 14%	11.7	--	11.7	11.6	--	11.6	11.8	--	11.8
Sparkling Wine	20.4	1.8	22.2	22.1	1.9	24.0	20.4	2.0	22.3
Total	237.3	30.0	267.4	269.1	36.2	305.2	289.9	47.0	337.0

Source: The Wine Institute.

TABLE A-14

WINE DEMAND BY TYPE, 1970 TO 1972

(In million wine gallons)

Type Wine	1970			1971			1972		
	Production	Import	Total	Production	Import	Total	Production	Import	Total
Table Wine	112.7	20.7	133.4	130.1	26.0	156.2	136.3	37.5	173.8
Dessert Wine	71.3	2.4	73.7	71.0	2.9	73.9	70.0	2.7	72.7
Vermouth	5.1	5.1	10.2	4.9	5.4	10.3	5.1	4.9	10.1
Other still wine									
Less than 14%	16.1	--	16.1	29.3	--	29.3	46.3	--	46.3
More than 14%	11.7	--	11.7	11.6	--	11.6	11.8	--	11.8
Sparkling Wine	20.4	1.8	22.2	22.1	1.9	24.0	20.4	2.0	22.3
Total	237.3	30.0	267.4	269.1	36.2	305.2	289.9	47.0	337.0

Source: The Wine Institute.

TABLE A-15

WINE CONSUMPTION, 1962-1980

Year	Glass Containers (Millions)			Wine Consumption
	Domestic [a]	Import	Total	(Millions of Gallons) [b]
1962	710	37	747	163
1963	750	39	789	171
1964	780	46	826	180
1965	780	46	826	183
1966	770	51	821	187
1967	820	53	873	197
1968	830	60	890	213
1969	970	71	1,041	235
1970	1,030	89	1,119	267
1971	1,150	107	1,257	305
1972	1,230	140	1,370	337
1975	1,360	170	1,530	387
1980	1,590	210	1,800	485
1985	1,650	250	1,900	570
1990	1,750	300	2,050	680

	Growth Rate - Percent per Year	
	Total Containers	Wine Consumption
1962-1972	6.2	7.5
1972-1980	3.5	4.6
1980-1990	3.0	3.5

Source: [a] Glass Container Manufacturers Institute, 1962-1972; MRI estimates, 1972-1980.

[b] The Wine Institute, 1962-1972; MRI estimate, 1972-1980.

All wine marketed in the United States is packaged in glass containers. Glass is desired because it provides a good barrier to oxygen and carbon dioxide; offers a shelf life of more than 1 year; and is approved by the FDA. It also provides product visibility and can be hot-filled and pasteurized when bottling. Domestic shipments of glass containers for wine amounted to 1.23 billion units in 1972. This does not represent all glass containers for wine since imports are important. There are no statistics available on the amount of imported wine bottled in the United States compared to that bottled in foreign countries. We assumed that the same ratio of foreign to domestic bottling applies to wine, as it does to distilled spirits, where 70 percent of the imports are bottled in foreign lands. Forty-seven million gallons of wine, equivalent to 14 percent of domestic consumption, were imported in 1972. This resulted in an additional 140 million containers, bringing the total use of glass wine bottles to 1.37 billion units.

There is a trend toward increasing container size as evidenced by the increasing average container weight. This will continue, and overall growth in containers will be 3.5 percent per year through 1980, when 1.80 billion containers will be used for wine (Figure A-10).

Glass containers have been the only consumer package for wine in the United States. However, PVC containers have been used to a large extent in Europe since the 1960's. Their shelf life is much less than glass containers and oxygen permeability is a problems. However, the demand for wine in Europe is much greater than in the United States and the turnover is quite rapid, so shelf life is not a real problem in Europe.

There are no indications of a trend toward a plastic container in the United States. Current research efforts on barrier resins should yield an acceptable product by 1980 that will meet the requirements of the industry and the FDA. It is possible that plastic containers may be imported into the United States from European wineries. However, a recent plan by a French wine producing conglomerate to market a rose red table wine in 48-ounce PVC bottles in the United States was halted by the FDA because of possible health hazards. Because of this action and the lack of other satisfactory resins, it will be 1980 before plastic containers become commercial for wine.

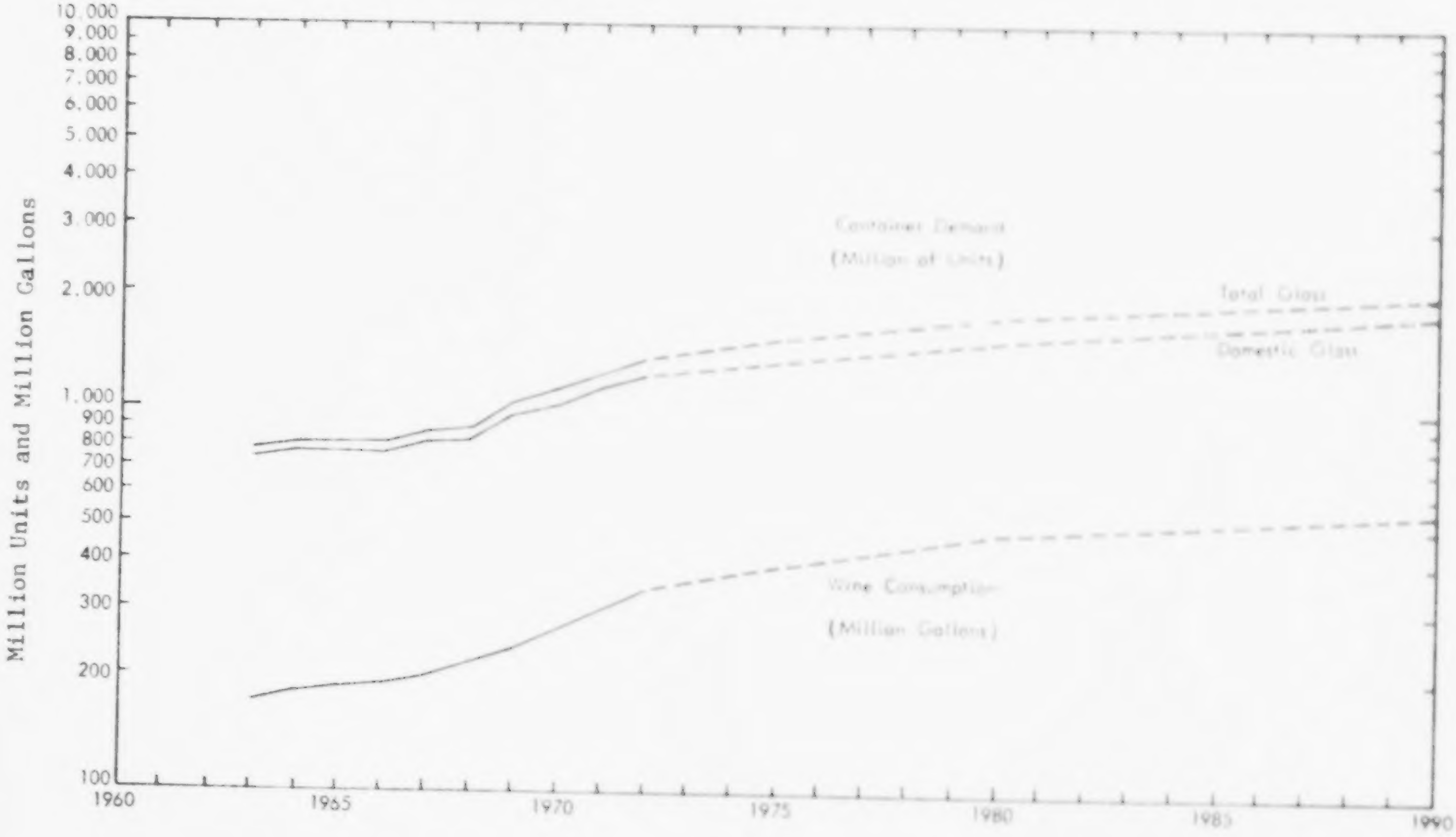

Figure A-10 - Wine Consumption and Container Demand, 1963-1990

THE FOOD INDUSTRY

Food is the nation's largest industry with consumer expenditures of $124.4 billion in 1972. This is equivalent to 15.7 percent of all personal consumption expenditures. Although food expenditures have increased from $70.1 billion in 1960, its share of the personal disposable income has declined from 20 percent in that year to the present level. Because of inflation and changing consumer preferences, per capita consumption of food has risen more slowly. The per capita consumption index for all foods has increased from 96.4 in 1960 to 103.7 in 1972, representing a real growth of about 1.85 percent per year in the actual weight of food consumed.

Food Consumption

The above figures include all fresh and processed foods which are nearly all contained in some form of rigid, flexible or filmed package. A wide variety of processed foods are packaged in metal cans and glass containers,although plastic containers are beginning to appear in this market to a limited extent. Nearly half of these containers are for canned foods such as soups, vegetables, fruits, fruit juices, and vegetable juices. Other smaller,but significant,markets include pet foods, baby food, canned meat and fish, condensed and evaporated milk, coffee and tea, salad dressings, pickles, vegetable oils, peanut butter, syrup and vinegar. These items represented a market for 44.0 billion rigid containers in 1972.

Processed foods have not shown much growth because of changing consumer preference toward more convenience foods and other forms of processed foods which reduce the amount of time the average housewife spends in the kitchen. Per capita consumption of some of the major products is shown in Table A-16. During the period from 1960 to 1972, per capita consumption of condensed and evaporated milk, lard and coffee have declined significantly. Canned fruits have been relatively stable,while canned vegetables and juices have had moderate growth. The decline in condensed and evaporated milk is a result of increasing preference for dry milk solids in institutions and at the consumer level. The decline in lard is attributed to the reduced amount of lard available from hog processing plants and to consumer preference for vegetable shortenings. Coffee consumption has declined because of consumer preference for the sweeter carbonated beverages.

The growth of food products packaged in containers should continue at slightly under 1 percent per year. A projection of consumer spending for various grocery products to 1980 is shown in Table A-17. Canned and jarred foods,which account for most of the products packaged in rigid containers, areexpected to increase from $12.7 billion to $16.5 billion by 1980. Growth,

TABLE A-16

PER CAPITA CONSUMPTION OF SELECTED FOODS, 1950 TO 1972

Type of Food	Pounds Per Capita						
	1950	1960	1965	1967	1970	1971	1972
Canned Fish	4.9	4.0	4.4	4.4	4.4	4.3	---
Condensed and Evaporated Milk	20.1	13.7	10.6	9.0	7.1	6.8	6.2
Lard	12.6	7.6	6.4	5.4	4.7	4.3	3.8
Canned Fruit	21.6	22.6	23.5	22.6	23.3	21.9	21.6
Canned Fruit Juices	13.5	13.0	10.9	11.7	14.2	15.4	15.6
Canned Vegetables	41.2	43.4	46.9	49.0	51.1	51.2	51.9
Coffee	16.1	15.8	14.9	14.8	13.8	13.3	13.9

Source: "National Food Situation," Economic Research Service, USDA; National Canner's Association.

TABLE A-17

CONSUMER SPENDING FOR GROCERY PRODUCTS, 1960 TO 1980

(In billion dollars)

Grocery Category	1960	1970	1980
Meat, fish, poultry	$14.8	$20.4	$25.6
Canned and jarred	9.4	12.7	16.5
Dry stuffs	5.5	7.1	9.2
Produce, fresh	4.4	5.7	7.2
Dairy, refrigerated	6.1	8.7	11.3
Bakery, fresh	3.5	5.1	6.1
Other foods	4.1	7.1	9.3
Total	$47.5	$66.8	$85.2
Frozen foods including ice cream	3.1	5.0	9.5
Total Foods	$50.6	$71.8	$94.7
Nonfoods	9.0	13.9	19.1
Total Grocery	$59.6	$85.7	$113.8

Source: Eastern Frosted Foods; Quick Frozen Foods.

which averaged 3 percent per year between 1960 and 1970, is projected at a rate of 2.6 percent between 1970 and 1980. The real rate of growth between 1960 and 1970 was 1.25 percent per year adjusted for inflation. Assuming the same rate of inflation during the next decade, the real growth would average 0.85 percent per year. Thus, a growth less than 1 percent per year during the next decade for food products packaged in metal cans, glass containers, and plastic bottles is realistic.

Food Processing

Most foods are preserved by heat sterilization or pasteurization to kill or inactivate harmful bacteria. The heat treatment is usually conducted in the filled and closed containers, with a temperature in excess of 230°F and the finished product is normally under a high vacuum. Products such as vegetables, baby foods, poultry, meat, fish and soups, which have a pH of 4.5 or greater, are canned by this method. Acid foods such as fruits, tomato products and juices are processed in the container at a lower temperature of 185-190°F, and at a vacuum of about 10 inches of mercury. Fruit juices and drinks are given a high temperature treatment and then hot or cold filled. Therefore, the package must have the following characteristics: it should have an excellent barrier to oxygen; it should be chemically and physically inert so that no flavor changes are in evidence; it must have a hermetic seal; it must be able to withstand processing conditions of high temperatures and pressure or vacuum.

Metal cans and glass have satisfactorily met these challenges and can also provide a shelf life of a year or longer. Glass containers have the added feature of allowing product visibility for merchandising appeal, but they are also breakable.

Food Containers

Glass containers and metal cans each have their own distinctive markets and there has been competition between them in only a few products. Metal cans are used for canning fruits, vegetables and their juices, evaporated milk, meats, poultry, fish, lard, soups and pet foods. Glass containers are used when product visibility or a resealable feature is desired. Salad dressings, horseradish, pickles, peanut butter, syrup, vinegar, jellies, catsup and baby foods are in this category. Some fruits and vegetables are packed in glass, but this is predominantly a can market. Soluble coffee and tea are packed in glass containers and vacuum packed coffee is packaged in metal containers.

Because of their unique properties, glass and metal cans have dominated this market. Its potential of 44 billion units represents a lucrative market for the development of a plastic container which would have the added advantages of being nonbreakable and light weight. However, the severe requirements of high temperature, pressure or vacuum packaging, low oxygen permeability, and visibility prevent most of the existing resins from competing in this market.

Recent developments of improved resins that meet some of the less severe requirements indicate that plastics may begin to penetrate this market in greater depth. PVC and polypropylene bottles are being used to package vinegar, syrup, mustard, vegetable oils and liquid margarines. The nitrile barrier resins have shown promise and are being evaluated in selected markets.

It is not expected that the PVC container will become a factor because of its high cost and potential problem of migration of the resin from the container into the product as experienced in the liquor container. Polypropylene containers will achieve a good growth because of their ability to be hot filled. These containers will compete with glass where clarity and a resealable feature are desired.

Food Container Demand

The demand for food containers has increased slightly during the past decade from 41.5 billion units in 1962, to 43.9 billion in 1972. Because of significant variations in the seasonal canning of fruits and vegetables, demand was as low as 39.6 billion in 1963, and as high as 44.4 billion in 1970. Average growth during this period was less than 1 percent per year (Table A-18).

Demand for food containers is projected to increase at 0.5 percent per year through 1980, to reach a level of 46.1 billion units. Most of the growth will be absorbed by plastic containers, as improved resins are developed to compete in additional markets (Figure A-11).

Metal cans: Metal cans make up close to 75 percent of this market and are used to contain a wide variety of foods. Demand in 1972 at 31.3 billion units was nearly the same as the 1962 use of 31.4 billion cans. Because of seasonal variations in food corps, the can demand varied from a low of 29.3 billion in 1965, to a high of 32.0 billion in 1970.

TABLE A-18

FOOD CONTAINER SHIPMENTS, 1962 TO 1990

(In millions of units)

Year	Glass[a]	Metal Cans[b]	Aerosol[a]	Plastic[a]	Total
1962	10,068	31,412	--	--	41,480
1963	10,072	29,428	70.0	21.9	39,592
1964	10,507	30,339	71.5	50.8	40,957
1965	11,023	29,281	89.7	56.9	40,488
1966	10,788	29,900	69.6	174.8	40,933
1967	11,872	29,787	100.5	99.2	41,847
1968	11,181	30,836	85.9	121.0	42,223
1969	11,901	30,811	88.3	202.1	43,001
1970	12,080	32,000	90.3	278.2	44,438
1971	11,763	31,400	85.6	458.1	43,724
1972	11,920	31,300	100.0	600.0	43,920
1975	12,210	31,500	120.0	1,000.0	44,830
1980	12,400	32,000	150.0	1,500.0	46,050
1985	12,400	32,500	180.0	2,000.0	47,080
1990	12,400	33,000	200.0	2,500.0	48,100

	Growth Rate Percent Per Year				
	Glass	Metal Cans	Aerosol	Plastic	Total
1962-1972	1.7	0.0	4.0	--	0.6
1972-1980	0.5	0.4	5.2	12.1	0.5
1980-1990	0.0	0.4	3.0	5.4	0.4

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a/ U.S. Department of Commerce, "Containers and Packaging", 1962-1972; MRI estimates, 1972-1990.

b/ Can Manufacturers Institute, 1962-1972; MRI estimates, 1972-1990.

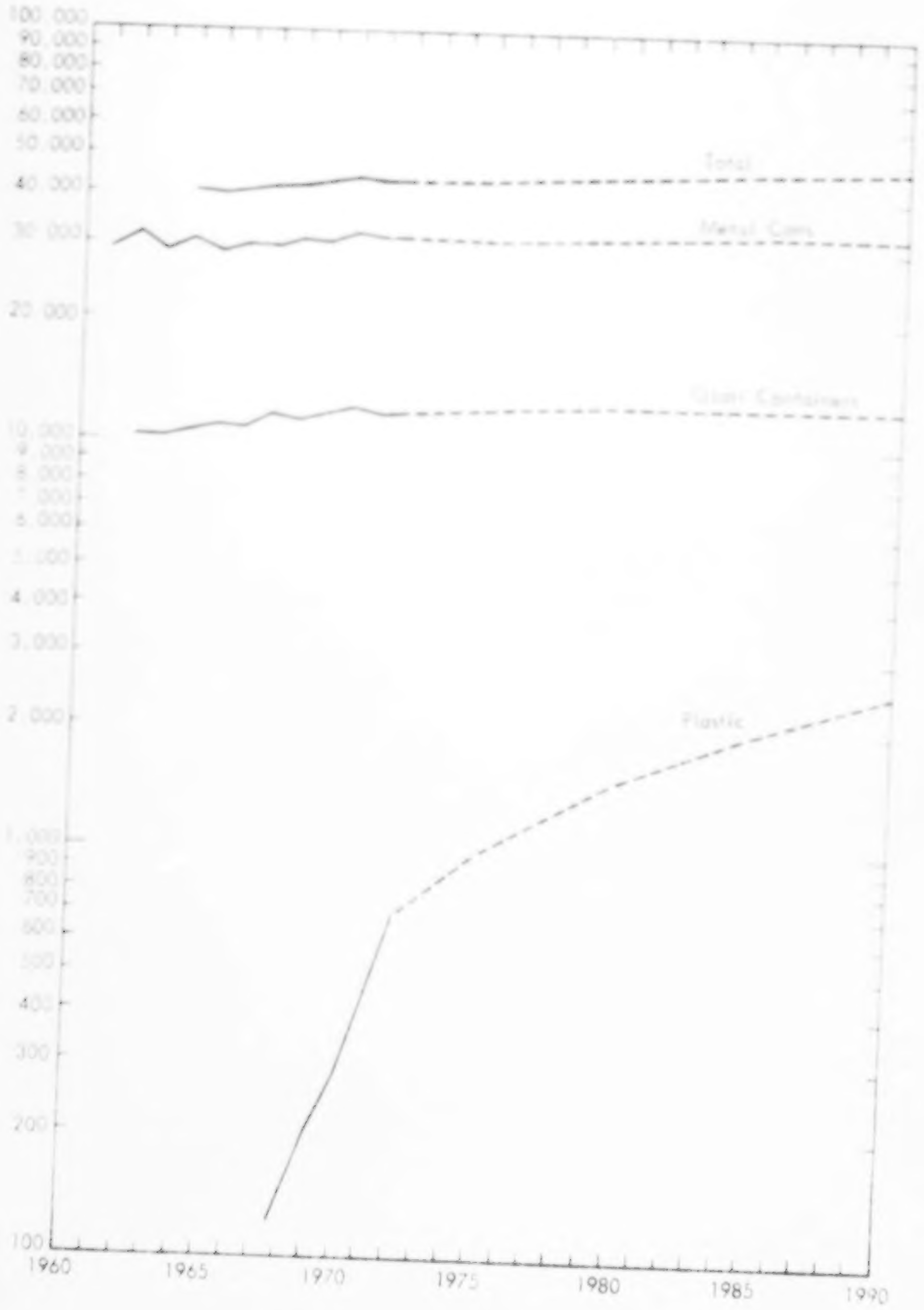

Figure A-11 - Food Container Shipments, 1961-1990

Although the total use of cans has been constant, the composition of the market has changed as shown (Table A-19). Only pet foods and baby food have shown any growth pattern, while fruit and fruit juices, evaporated and condensed milk, lard and shortening and coffee have declined appreciably.

TABLE A-19

CANNED FOOD SHIPMENTS, BY TYPE, 1962 TO 1972
(In million units)

Type of Food	Millions of Cans		Increase	
	1962	1972	Millions	Percent
Fruit and Fruit Juices	7,384	5,788	(1,596)	(21.6)
Vegetables and Juices	8,176	9,200	1,024	12.5
Evaporated-Condensed Milk	2,196	1,420	(776)	(35.3)
Other Dairy Products	242	203	(41)	(16.9)
Meat and Poultry	1,393	1,733	340	24.4
Fish and Seafoods	1,813	1,661	(152)	(8.4)
Lard and Shortening	413	302	(111)	(26.8)
Baby Food and Formulas	509	860	351	69.0
All Other Food & Soups	6,016	5,740	(276)	(4.6)
Coffee	1,054	839	(215)	(20.4)
Pet Food	2,216	3,567	1,351	60.9
Total	31,412	31,313	(99)	(0.3)

Sources: Can Manufacturers Institute; U.S. Department of Commerce, "Containers and Packaging."

This changing product mix will continue through 1980 and demand will increase only at a rate of 0.4 percent per year to a level of 32.0 billion cans by 1980, and 33.0 billion by 1990. The average size should not change, with a trend to the larger "family sizes" in some fruits and vegetables offset by the development of pull-top, 5-ounce, single service cans for puddings and specialty foods.

Aerosol food containers, which never developed into the markets projected for them, amount to about 100 million units per year and should increase to 150 million by 1980.

Glass containers: Glass containers amount to 25 percent of the food market and have increased from 30.1 billion units in 1962 to 31.9 billion in 1972, for a growth rate of 1.7 percent per year. There is no available published information on the number of containers for each food category. It is estimated that the largest volume markets are baby foods, salad dressings, pickles, jellies and jams, ketchup and meat sauces.

Demand for glass containers is projected to increase at 0.5 percent per year, to reach a level of 32.4 billion units by 1980 and remain at this level. Much of the growth that would have occurred during this period will be achieved by plastic containers which have already penetrated the syrup, vinegar and cooking oil markets where large containers are used.

Plastic containers: Plastic containers amounted to 600 million units in 1972. About 300 million were polyethylene beverage containers used for noncarbonated soft drinks and juices. The balance include PVC and polypropylene used for packaging vinegar, syrup, vegetable oils, and liquid margarines.

Growth of plastic containers will be steady, but not rapid, due to the severe requirements of the food industry. Demand should reach a level of 750 million by 1980, and then could increase more rapidly beyond 1980 if a good barrier resin with the strength and high temperature resistance is developed.

Fluid Milk Packaging

Fluid milk, although part of the food industry, is a distinct entity as it relates to containers. Fluid milk consumption has been declining slowly from 53.3 billion pounds in 1962 to 51.8 pounds in 1972. Consequently, per capita consumption has declined--from 285 pounds in 1962 to 252 pounds in 1972. Relatively little change is seen in the trend of milk consumption during the next 1.5 decades as per capita consumption continues to decline because of consumer preference for sweeter carbonated drinks, and other beverages.

Milk packaging has been affected by consumer demands for larger size containers and the trend toward purchases at supermarkets, rather than through home delivery. Wholesale milk sales have increased from 72 percent of the total in 1964, to 85 percent in 1971 (Table A-20). Indications are that this trend will continue toward a larger percentage of milk being purchased through wholesale markets. Historically, home delivered purchases have been in returnable glass containers, and milk sold through supermarkets (wholesale) was predominantly in paper containers. However, home delivery now is commonly in paperboard, plastic or glass.

TABLE A-20

FLUID MILK DISTRIBUTION BY MARKET SEGMENT, 1964 AND 1971

(Percent by volume)

Market Segment	Percent 1964	 1971
Wholesale	72	85
Retail	28	15
Total	100	100

Source: Dairy Situation, USDA, November 1972.

FLUID MILK DISTRIBUTION BY CONTAINER SIZE, 1964 AND 1971

(Percent by volume)

Size Unit	Percent 1964	 1971
Gallon	16	29
Half Gallon	53	43
Quart	13	10
Pint	2	2
Half Pint	10	11
Other	1	1
Bulk	5	4
Total	100	100

Source: Dairy Situation, USDA, November 1972.

Average package sizes are increasing as indicated in Table A-21. Gallon containers, which accounted for 16 percent of total milk in 1964, increased to 29 percent in 1971, primarily at the expense of the half gallon units.

TABLE A-21

FLUID MILK DISTRIBUTION BY CONTAINER TYPE

(Percent by volume)

	1964	1971	1980
Paper	64.0	78.4	21.0
Glass	30.0	6.6	--
Bulk Can	3.0	0.4	--
Plastic Bag in Box	3.0	4.0	4.0
Plastic Container	--	10.7	75.0
Total	100.0	100.0	100.0

Source: Dairy Situation, 1964-1971, USDA, November 1972; 1980 estimate Hoover Ball and Bearing Company, "Milk Packaging Trends in the Dairy Industry," The Wall Street Transcript, April 9, 1973.

The most significant changes have occurred in the type of container as shown in Table A-22. Glass containers, which accounted for 30 percent of sales in 1964, declined rapidly to 6.6 percent in 1971. Paper, which was 64 percent in 1964, increased its share to 78.4 percent during the same period. However, the most rapid development has been the plastic blow molded polyethylene container, which accounted for nearly 11 percent in 1971, from its initial marketing in 1964.

TABLE A-22

COMPARATIVE COST OF RAW MATERIALS FOR MILK CONTAINERS

(In $ per thousand)

Container Size	Paper	Plastic	Plastic Weight
Half Pint	$ 7.19/M	$ 2.42/M	8 grams
Half Gallon	24.38/M	12.13/M	40 grams
One Gallon	48.08/M	24.26/M	80 grams

Source: "Milk Packaging Trends in The Dairy Industry," The Wall Street Transcript, April 9, 1973.

More recently, a plastic returnable milk container has been test marketed in the U.S.A. It reportedly will make up to 50 trips. Should this container gain in acceptance, it could completely change our forecasts given in Table A-21 because the one-way container market could decline appreciably.

A number of factors have accounted for the growth of the one-way polyethylene container. The development of blow molding equipment, which can be installed in the milk plant, the trend to larger sized gallon containers, the increasing size of dairy plants, and the decreasing cost of polyethylene resins have all contributed to this growth. Most of the growth has come at the expense of the returnable glass container, which should be replaced completely by polyethylene by 1980. More significantly, polyethylene containers are reported to be competitive with paper containers. In fact, the comparative cost of plastic and paper for various sized containers indicates plastics are lower cost, assuming a 13-1/2 cents per pound cost of resin (Table A-22). At this price, raw material costs for plastic are nearly half the cost of paper. Even with additional costs for closures that will vary from $1.80 to $8.00 per thousand, and the cost of labor and amortization of the equipment, the total costs are favorable to polyethylene containers.

It is possible that this relative cost difference will not change during the next 2 decades and that polyethylene containers will continue to increase their share of this market. Estimates, as shown in the Table A-21, indicate that by 1980 plastic containers will have 75 percent of the market with the balance being paper containers. However, we must raise serious question whether this forecast will hold up in the wake of the "energy crisis" and moves by the paperboard producers to preserve this market.

It should also be noted that about 4 percent of the market consists of plastic-bag-in-a-box containers for larger 5-10 quart sizes. The development of this container for the home refrigerator never achieved a large commercial success and its share has been relatively consistent during this period. With the trend toward smaller families and a decreasing per capita consumption, we do not envision that this share will increase during the next 2 decades.

HOUSEHOLD AND INDUSTRIAL CHEMICALS

A wide variety of household and industrial chemicals are used by consumers, institutions, and industrial firms. Major consumer products are liquid detergents, bleach, insecticides, room deodorants, polishes and waxes, starch, ammonia, window cleaners, disinfectants, inks and dry cleaning spot removers. Industrial chemicals include a wide variety of commercial and research chemicals such as acids, dyes, reagents and solvents used in various industrial and institutional establishments.

This was originally a glass container market since the inertness of glass made it a desirable container for products which were corrosive or toxic. However, glass is breakable and the hazardous nature of many of these products made it an ideal market for the introduction of blow molded plastic containers. It also was the first volume market for blow molded containers.

Liquid detergents and bleach were the first consumer markets to convert, and today, are nearly all packaged in plastic containers. These products represent 55 percent of all plastic containers used for household and industrial chemicals.

After penetration into these markets, other cleaning preparations such as fabric softeners, starch, floor wax, ammonia, and the dry powdered cleaning products such as bowl cleaners and drain cleaners, were converted to plastics. Plastic containers have now captured most of the glass container markets where product compatibility does not present a problem. Current conversions include window cleaners, where a clear plastic is desired, and insecticides, where product compatibility is not a problem.

Industrial chemical containers amount to about 10 percent of the household chemical containers and include a wide variety of chemicals and industrial detergents used by industrial and commercial firms. Many of these are large, reusable containers found in research and testing laboratories.

Metal aerosol containers have become a significant factor in the consumer convenience markets. They are used for insecticides, room deodorants, cleaners, waxes, polishes and starches. The methods of use of these products make them ideal for aerosol systems and they have been readily accepted by the consumer.

The historical and projected growth of household and industrial chemical containers is shown in Table A-23. Demand has increased at 4.5 percent per year since 1963, the first year in which plastic container shipments were reported by the Department of Commerce. This growth rate was more rapid during the early part of the decade, and since 1967, has been growing at 3 percent per year. Container use has grown from 3.0 billion units in 1963, to 4.24 billion units in 1972.

The future growth rate of household and industrial chemical containers will approach population growth because of the lack of new product innovation and the saturation of most existing markets. Demand should grow at 1.9 percent per year between 1972 and 1980, and decrease to a rate of 1.7 percent per year through 1990. Correspondingly, container use will reach 5.01 billion units in 1980, and 5.9 billion in 1990 (Figure A-12).

TABLE A-23

HOUSEHOLD AND INDUSTRIAL CHEMICALS CONTAINER SHIPMENTS, 1962 TO 1990

(In millions of containers)

Year	Glass	Plastic	Aerosol	Total
1962	1,358	*	232	*
1963	1,278	1,389	296	2,963
1964	1,061	1,618	466	3,145
1965	991	1,773	571	3,335
1966	837	2,049	622	3,508
1967	816	2,175	670	3,661
1968	624	2,380	664	3,669
1969	648	2,508	701	3,857
1970	615	2,714	728	4,057
1971	562	2,737	732	4,032
1972	608	2,850	830	4,290
1975	500	3,150	895	4,545
1980	500	3,450	1,060	5,010
1985	500	3,800	1,170	5,470
1990	500	4,150	1,285	5,935

Growth Rate %/year	Glass	Plastic	Aerosol	Total
1963-1972	(8.6)	8.3	10.5	4.5
1972-1980	(2.5)	2.4	2.5	1.9
1980-1990	0	2.0	2.0	1,7

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* Not reported.

Source: U.S. Department of Commerce, "Containers and Packaging," 1962-1972.
Midwest Research Institute estimates, 1972-1990.

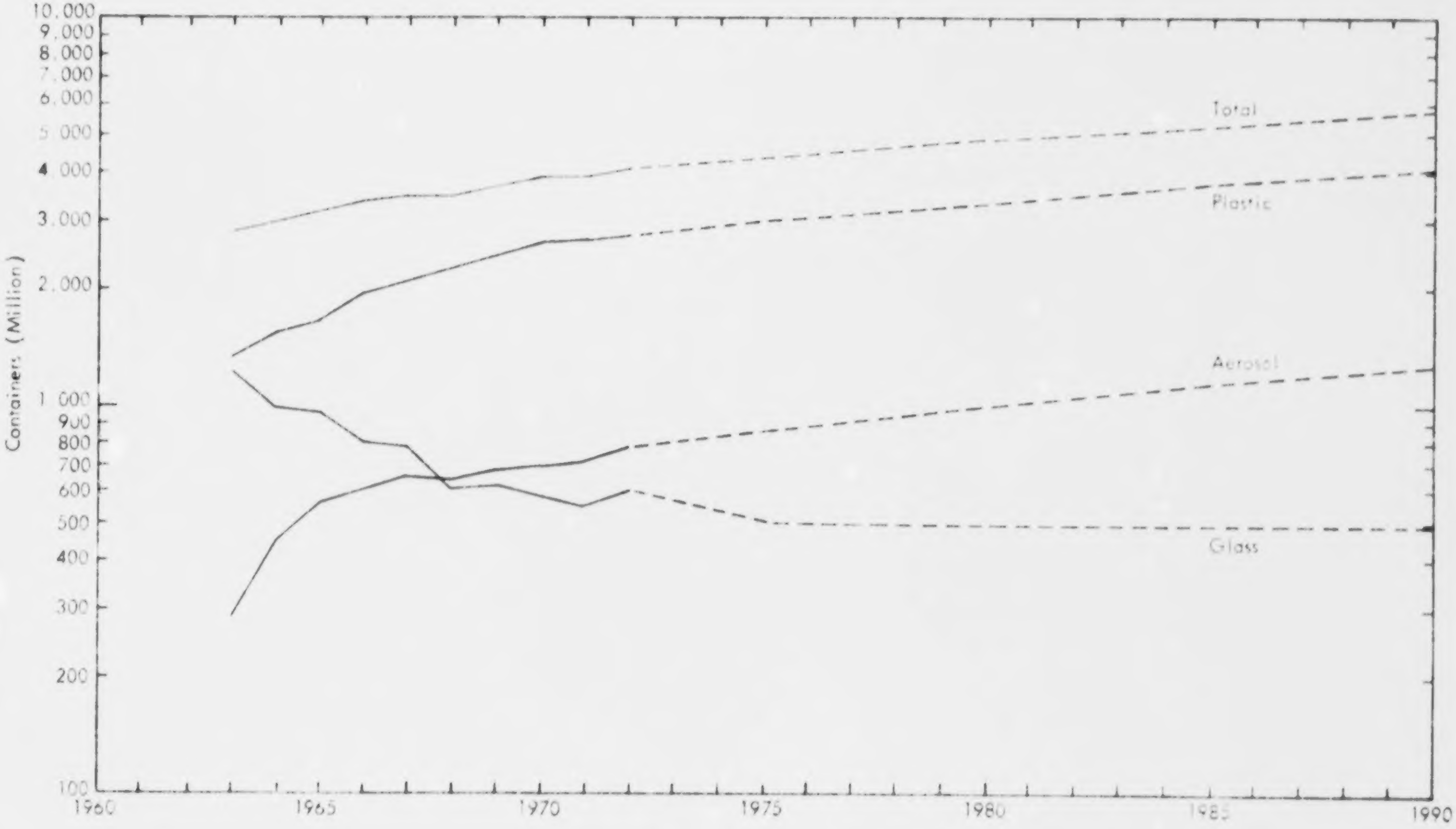

Figure A-12 - Household and Industrial Chemical Container Shipments, 1963-1990

Plastic containers have grown at a rate of 8.3 percent since 1963. This rate of growth has been decreasing, and during the last 5 years was at 5.5 percent per year. Consumption reached 2.84 billion units in 1972, equivalent to two-thirds of the household and industrial chemical market. Plastic containers have about reached their limit of penetration into the glass market, and with the exception of the conversion of window cleaning products, selected insecticides, and scouring powder demand will slow to a level slightly above population growth. Growth will be at 3.5 percent per year to 1975, and 2 percent per year through 1990. This will generate a demand for 3.45 billion containers in 1980 and 4.15 billion in 1990.

Aerosol containers grew rapidly during the early part of the decade because of product innovations. Since 1962, when 232 million units were filled, the growth has averaged 10.5 percent per year, reaching a level of 830 million in 1972. Growth has been slowing and during the last 5 years averaged 4.6 percent per year. A lack of new product innovations and market saturation will limit future growth to 2.5 percent per year through 1980. Demand will reach 1.06 billion units in 1980, and 1.29 billion by 1990.

Glass containers reached their highest volume in 1959, when 1.92 billion units were filled. Since that time, they have declined steadily to a level of 600 million units in 1972. Most of the shift in markets to plastic and aerosol containers has been completed, and a slight decline to 500 million units is projected by 1975, where it will remain through 1990. Products such as furniture polish, dry cleaning spot removers, naptha based insecticides and disinfectants, are still contained in glass. Hydrocarbon based plastics will not contain naptha based chemicals, and with other products that are sensitive to light or have strong solvent characteristics, should continue to be packaged in glass.

TOILETRIES AND COSMETICS

Toiletries and cosmetics include a wide variety of personal care products. It is a highly stylized and rapidly changing market where packaging is very important to the sale of the product. Products are heavily advertised and many are aimed at the youth market. The packages are creatively designed in colors and molded shapes so that they are easily recognizable by the consumer.

The toiletry and cosmetic market has been a haven for new product development. Originally, most cosmetics were packaged in glass or metal containers. The development of the aerosol and blow molded plastic containers has allowed the packager a wide degree of freedom in package design.

Hair sprays, deodorants, antiperspirants, shaving lotion, cologne and perfumes are popular in aerosol spray form. Sun tan oil, shampoos, hair colors, lotions, dry powders, and baby oils are popular in plastic containers. Men's shaving lotion, nail polish, cold cream, make-up, perfume and colognes are popular in glass containers.

Toiletries and cosmetics that are packaged in aerosol containers and shown in Table A-24 are mostly personal care products. Hair care products, deodorants, and antiperspirants are the most popular items, amounting to 68 percent of all personal aerosol products. The balance is made up of shaving lathers, colognes, perfumes, medicinal, and pharmaceutical products. Growth of aerosols was most rapid during the early decade, increasing at 17 percent per year from 1963 to 1970. The growth rate has slowed as the markets matured, and during the last 5 years grew at a more modest rate of 7.5 percent per year. With existing products reaching maturity and the lack of significant new product developments, demand should grow at 4.9 percent per year through 1980 and decline to 2.5 percent per year rate through 1990. This would generate demand for 2.1 billion units in 1980 and 2.7 billion in 1990.

TABLE A-24

AEROSOL PERSONAL CARE PRODUCTS BY TYPE, 1971 TO 1973
(In million units)

Type Product	1971	1972	1973a/
Shaving Lathers	159	162	166
Hair Care Products	451	480	490
Medicinals and Pharmaceuticals	56	60	64
Colognes and Perfumes	134	140	147
Deodorants and Antiperspirants	468	505	520
Others	76	90	105
Total	1,344	1,437	1,492

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a/ Forecast.

Source: E. I. du Pont Company.

Plastic container usage in toiletries and cosmetics has grown rapidly during the last decade from 416 million units in 1963 to 1.38 billion in 1972. Much of this growth has been at the expense of glass containers, which have been replaced by plastic in hair colors, lotions, baby oils, shampoos, and selected perfumes. The growth of plastic containers was quite rapid between 1963 and 1969. Since 1969, growth has been erratic, declining from that year's peak of 1.40 billion units to 1.12 billion units in 1970 and 1971, before increasing again to 1.38 billion units in 1972. This may be due to inaccurate reporting since many firms have installed blow molding equipment to manufacture their own containers and may not be reporting their production. Plastic containers are expected to continue their in-roads into glass markets as well as develop new markets in the ever changing cosmetic business. Growth is projected at 12.4 percent per year from 1972 to 1980. Beyond 1980, growth will begin to slow to a rate of 5 percent through 1990. Plastic containers should reach a level of 2.1 billion units in 1975, and increase to 3.5 billion units in 1980.

Glass container shipments which reached their peak in 1966, with a volume of 2.3 billion units, have declined sharply to a level of 1.3 billion units in 1972. Glass has lost much of the larger container market, but still maintains a preferred position in shaving lotions, nail polish, cold cream, make-up, perfume and cologne, and numerous cream and gel products packaged in opal jars. With the exception of nail polish, there is little problem of product compatibility; therefore, these markets are vulnerable to further penetration by plastic containers. It is anticipated that demand for glass containers will continue to decline to a level 1.1 billion units in 1975, and 1 billion units by 1980.

The growth rate for rigid toiletry and cosmetic containers was rapid during the early 1960's, but has been erratic since 1967. The overall growth rate between 1963 and 1972 was 3.8 percent per year, increasing from 2.97 billion units in 1963 to 4.17 billion in 1972. Total containers have probably grown at a faster pace since injection molded plastics, which are used in many small containers, are not reported separately and are not included in production statistics. These containers have replaced numerous glass containers.

Demand for all containers is projected to increase at 6.0 percent per year through 1980, and 3.3 percent from 1980 to 1990. This will result in a market for 6.37 billion containers in 1980 (Table A-25 and Figure A-13).

DRUGS AND PHARMACEUTICALS

A wide variety of medicinal and health products are packaged in containers. Aspirin, cold tablets, cough syrups, vitamin concentrates, antacids, mouth washes, milk of magnesia, mineral oils and prescription drugs are packaged in over 4 billion plastic, glass, and metal containers each year.

TABLE A-25

TOILETRY AND COSMETIC CONTAINER SHIPMENTS, 1962 TO 1990
(In millions of containers)

Year	Glass	Aerosols	Plastic	Total
1962	2,045	--	--	--
1963	2,026	530	416	2,972
1964	2,106	607	525	3,238
1965	2,194	906	579	3,679
1966	2,299	891	784	3,974
1967	2,291	1,000	962	4,253
1968	1,841	1,174	1,128	4,143
1969	1,817	1,288	1,401	4,506
1970	1,673	1,380	1,120	4,173
1971	1,284	1,344	1,136	3,736
1972	1,336	1,437	1,375	4,148
1975	1,120	1,660	2,100	4,880
1980	1,000	2,100	3,500	6,600
1985	850	2,380	4,460	7,690
1990	700	2,700	5,700	9,100

Growth Rate %/year	Glass	Aerosols	Plastic	Total
1963-1972	(4.8)	15.6	14.5	3.8
1972-1980	(3.7)	4.9	12.4	6.0
1980-1990	(3.6)	2.5	5.0	3.3

Source: U. S. Department of Commerce, "Containers and Packaging," 1962-1972. MRI estimates 1972-1990

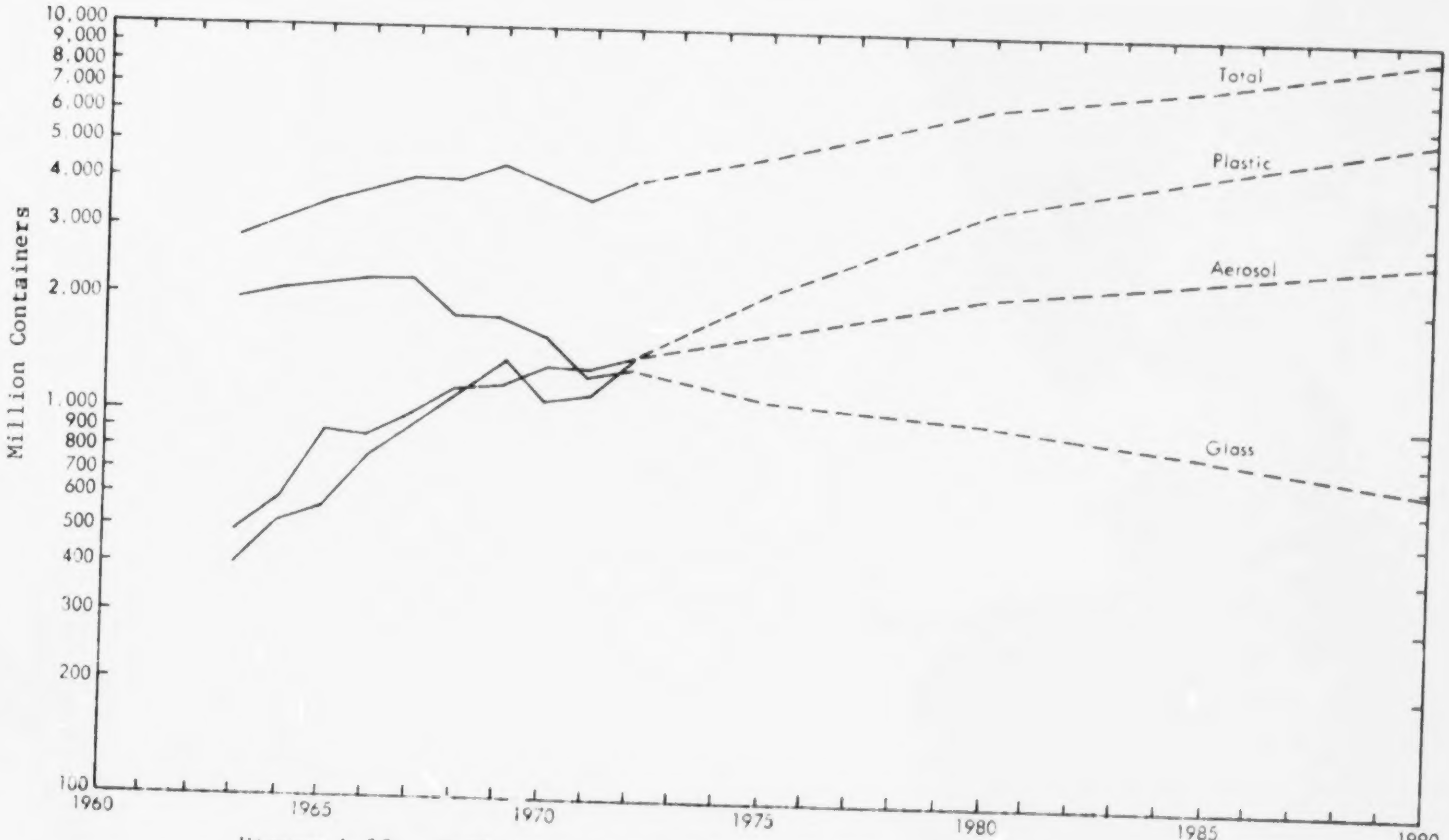

Figure A-13 - Toiletry and Cosmetic Containers, 1963-1990

Glass containers have dominated this market because they meet the requirements of the industry for a container that will protect the product against light, oxygen and water vapor transmission, have FDA approval, be inert to the contents, and in many cases, offer visibility to the product.

Plastic containers have successfully challenged glass in numerous products such as aspirin, mouth washes, vitamins, antacids, alcohol, nasal sprays, and petroleum jelly. Most of the plastic containers are blow molded, although an increasing number of polystyrene containers are produced by injection and other molding methods.

Glass container shipments in 1972 amounted to 2.97 billion units, a decline from the peak 1966 year when 3.42 billion were shipped. The increasing penetration of plastic containers will cause a further decline to 2.73 billion units by 1980. Glass containers are still favored for cough syrup, milk of magnesia, selected vitamins and biologicals (Table A-26 and Figure A-14).

Plastic blow molded containers have grown from a level of 142 million units in 1963, to 1 billion in 1972. Most of this growth has occurred since 1970, when numerous conversions were made to plastics. Blow molded containers are projected to increase rapidly during the next decade because of the trend to blow molding by the major drug firms. The equipment for these containers is being installed and will be producing in the near future. Demand for plastic containers is projected to grow 14.2 percent per year to 2.9 billion units by 1980.

It should be noted that the number of plastic containers is larger than the above figures, which represent only blow molded containers reported by the Department of Commerce. Numerous other plastics manufactured by other methods are competing for these markets. There are no available statistics by end use of these containers, but, although significant in terms of numbers, they are small in terms of resin consumption.

GENERAL PACKAGING

General packaging includes all other metal cans, aerosols and metal containers not included in previous sections. These categories consist of automotive and marine products such as oil, antifreeze, and aerosol products; coatings and finishes, which are primarily consumer paints and other coatings; and a wide variety of miscellaneous products.

TABLE A-26

DRUG AND PHARMACEUTICAL CONTAINER SHIPMENTS, 1962 TO 1990

(In millions of containers)

Year	Glass	Plastic	Aerosol	Total
1962	3,253	--	--	--
1963	3,108	142	38	3,288
1964	3,188	143	28	3,359
1965	3,393	265	35	3,693
1966	3,428	299	37	3,764
1967	3,254	327	41	3,622
1968	2,896	337	40	3,263
1969	3,355	401	46	3,802
1970	3,259	742	49	4,050
1971	2,697	892	43	3,632
1972	2,971	1,000	50	4,021
1975	2,880	1,500	60	4,440
1980	2,730	2,900	75	5,630
1985	2,670	3,800	90	6,550
1990	2,600	5,000	100	7,600

Growth Rate	Glass	Plastic	Aerosol	Total
1963-1972	(0.5)	24.2	3.1	2.5
1972-1980	(1.0)	14.2	5.2	4.3
1980-1990	(0.5)	5.6	3.2	3.0

Source: U. S. Department of Commerce, "Containers and Packaging," 1962-1972. MRI Estimates 1972-1990.

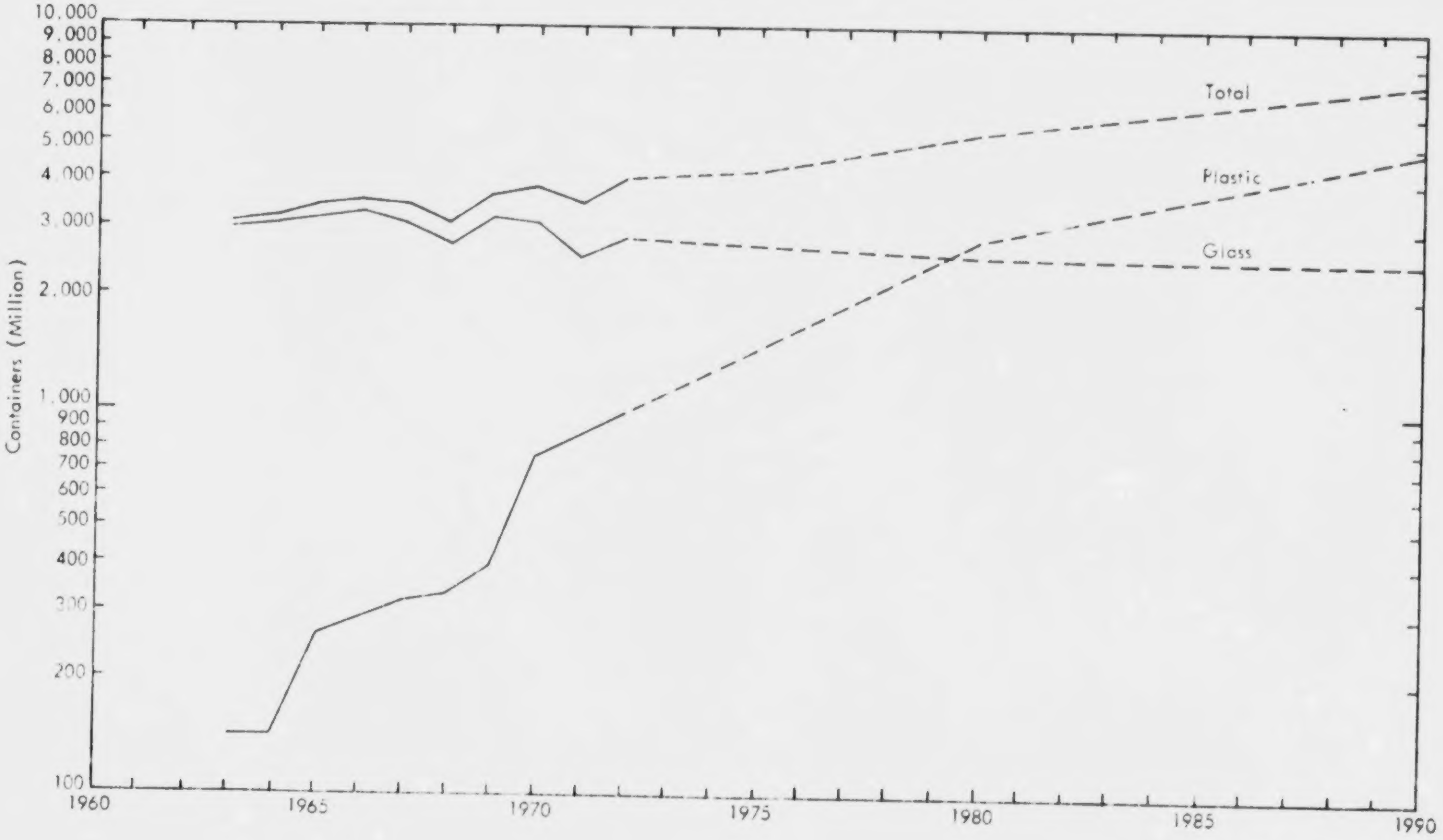

Figure A-14 - Drug and Pharmaceutical Container Shipments, 1963-1990

Automotive and Marine

An estimated 1.14 billion containers were used in 1972 for automobile and marine oils, antifreeze, and aerosol automotive products such as deicers, waxes and polishes (Table A-27).

The market for motor oil cans has changed significantly. Initially, it was a standard tin plate container, but by 1960, aluminum cans began to achieve a major penetration. However, by 1963 and 1964 the lower cost composite fiber foil containers were introduced, and today are the major container in this market. The demand for the steel metal can in 1972 is about the same as 1964 when most of the conversion was complete.

About 20 million plastic containers are used for motor oil and their demand has been constant since 1964.

We do not anticipate any growth for motor oil metal or plastic containers, and 1980 demand will be similar to the 1972 demand.

Antifreeze has essentially been a metal can market until recently, when the plastic container rapidly replaced the can in numerous brands. This has been particularly strong in retail stores, where over half of the antifreeze is marketed. Metal can demand declined 25 percent in 1972 over 1971, to an estimated 85 million units, while plastic containers increased to 70 million. This trend should continue as metal cans are continually replaced.

Aerosol automotive specialties amounted to 75 million units in 1972, and consist of windshield deicers, waxes, polishes and cleaners. Growth will increase the number to 100 million units by 1975, and 150 million by 1980.

Coatings and Finishes

Containers for coatings and finishes include metal paint cans and aerosol spray paint cans. These containers amounted to 901 million units in 1972, an increase of 132 million units since 1962 (Table A-28).

The steel paint can in gallons, quarts and pints has been the industry accepted container for many years. Growth has been steady and very little innovation has taken place. Plastic containers have been recently introduced in the markets, but are still under evaluation. Various systems are being tested to provide an easy-open lid that can be resealed.

TABLE A-27

AUTOMOTIVE AND MARINE CONTAINER SHIPMENTS BY TYPE, 1962 TO 1980
(In million units)

Type of Container	1962	1972	1975	1980
Metal oil cans	1,576	875	850	850
Metal antifreeze cans	138	85	75	50
Plastic containers	20	100	125	150
Aerosol containers	20	75	100	150
Total	1,754	1,135	1,150	1,200

Source: Can Manufacturers Institute, 1962-1972.
U.S. Department of Commerce, "Containers and Packaging," 1962-1972.
Midwest Research Institute estimates, 1972-1980.

TABLE A-28

METAL PAINT CAN SHIPMENTS BY TYPE, 1962-1980
(In million units)

Type of Container	1962	1972	1980[c]
Metal paint cans[a]	644	646	700
Aerosol paints[b]	104	255	400
Total	769	901	1,100

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[a] Can Manufacturers Institute, 1962-1972.

[b] U.S. Department of Commerce, "Containers and Packaging," 1962-1972.

[c] Midwest Research Institute.

Aerosol paints have had a modest growth. These products are available in sizes ranging from 6 to 20 ounces. They are primarily used for touch up and for applying clear protective coatings and varnishes.

Consumption should increase to 1.1 billion units by 1980, as demand continues to increase. Beyond 1980, plastic containers will become accepted and partially replace steel cans. However, total growth will increase only modestly during this period.

Miscellaneous Metal Cans

Approximately 3.15 billion metal cans were used in 1972 for a myriad of packaging uses. Medicinal and health products, household and industrial chemicals, tobacco products, turpentine, shoe polish, and a wide variety of consumer products are some examples. Demand for these containers has been static during the past decade and is not expected to grow in the future.

APPENDIX B

TRENDS IN THE DEMAND FOR FERROUS SCRAP IN IRON AND STEEL PRODUCTION

Introduction

Scrap consumed in the production of raw steel has averaged about 50 percent of total steel production over the past 20 years. Scrap produced in the steelmaking process ("home scrap"), however, provides the main source of scrap, with the percentage of scrap purchased from outside markets declining. Increased demand for ferrous scrap created by increasing steel production have been largely met by the proportionately larger quantity of home scrap generated. Thus, outside purchases of old scrap have remained at about the same level. Figure B-1 shows generally how the industry's scrap requirements are met.

The future role of scrap in steelmaking will be tied closely to technological developments. The types of scrap used in iron and steelmaking vary considerably with the type of furnace used, operating practice, scrap quality and price, the iron or steel product, and past practice. The proportion of the charge,consisting of scrap for the open hearth, basic oxygen, and electric furnaces,is 40-45 percent, 30 percent, and 98 percent, respectively, and has not changed significantly over the past 10 years. The principal factors governing scrap usage are related to operating practices and the size, shape, bulk density, and impurities present in the scrap. Obsolescent scrap occurs in many physical and chemical conditions and presents the greatest problems in scrap quality. Processing (shredding, separation, compaction, etc.) is required to obtain usable forms of scrap.

Blast furnace: In typical blast furnace practice in the U.S., the scrap consumed is about 5 percent of the pig iron produced. Research in this area could probably result in larger scrap charges.

Open-hearth (OH) steelmaking: Open-hearth steelmaking in the U.S. currently accounts for about 35 percent of the total steel production. An intrinsic feature of the open-hearth furnace is its versatility in raw materials, permitting scrap usage in any amount from zero to nearly 100 percent; typically, it has been about 45 percent. However, the higher efficiency and production rate of the basic oxygen furnace has caused a steady decline in open-hearth steelmaking which is expected to continue. For this reason, scrap recycling in open-hearth furnaces will decline in the future.

Basic oxygen furnace (BOF) steelmaking: BOF steelmaking in the U.S. currently accounts for about 50 percent of the total steel production. The BOF process is less versatile than open-hearth steelmaking and is limited by current industry practice and economics to scrap charges of about 30 percent. This is because no external fuels are used and heat is obtained by the rapid, exothermic oxidation by oxygen blowing of carbon, silicon, and manganese in the pig iron. The heat balance is the major scrap limitation, since only the excess heat over that required to bring

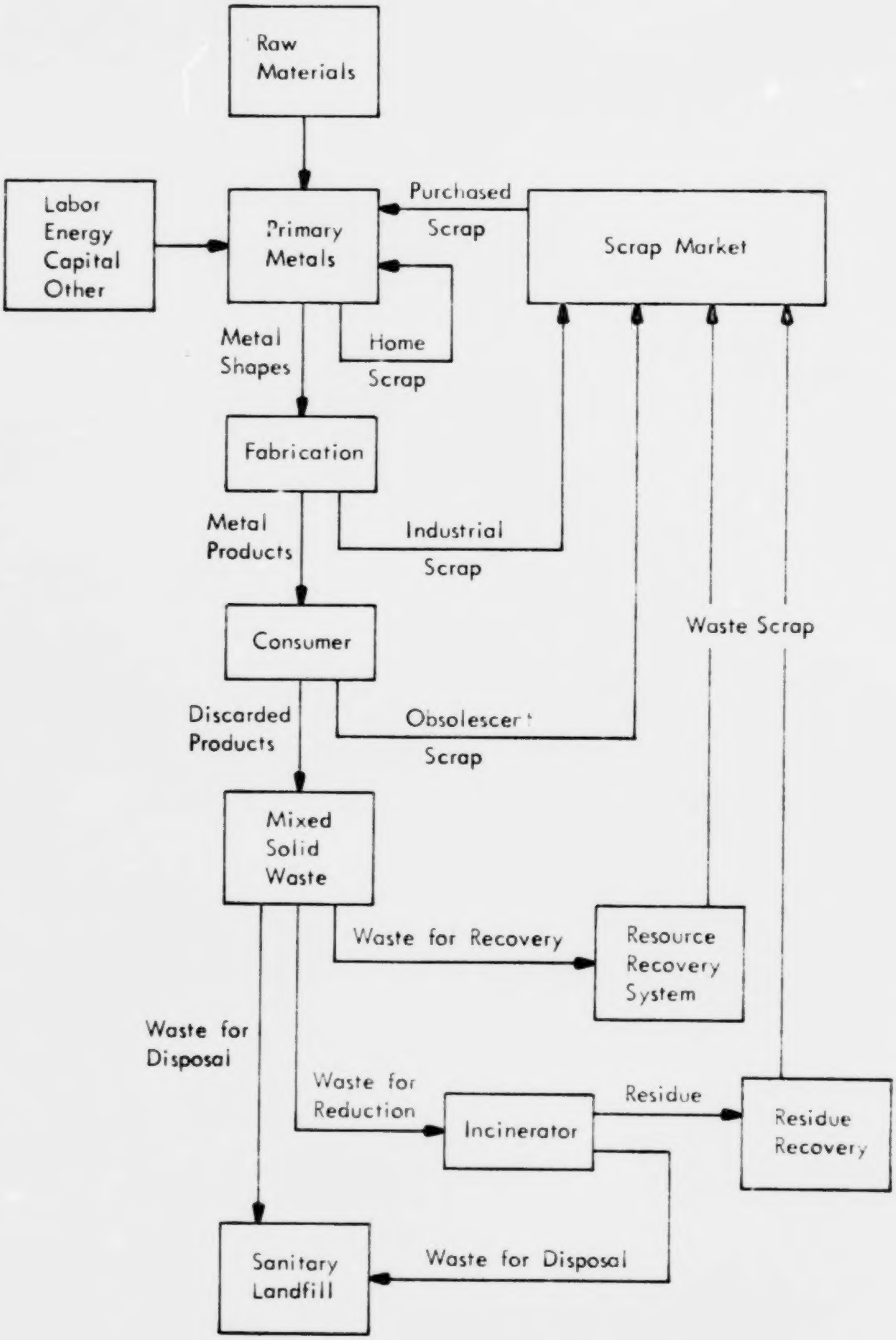
Raw Materials
Labor Energy Capital Other
Primary Metals
Purchased Scrap
Scrap Market
Metal Shapes
Home Scrap
Fabrication
Metal Products
Industrial Scrap
Consumer
Waste Scrap
Discarded Products
Obsolescent Scrap
Mixed Solid Waste
Waste for Recovery
Resource Recovery System
Waste for Disposal
Waste for Reduction
Incinerator
Residue
Residue Recovery
Sanitary Landfill
Waste for Disposal

Figure B-1 - Flow of Primary Metal and Scrap for Ferrous Metals the steel to the tapping temperature is used to melt the scrap. Scrap also tends to extend the charge-to-tap time and thereby reduces production rates. Various schemes of preheating scrap or supplying external supplies of heat have been, and continue to be, investigated in an effort to increase scrap charges in the basic oxygen furnace.

Electric furnace steelmaking: The electric furnace currently produces about 15 percent of the total U.S. steel production. This process uses an average of 98 percent scrap in the charge. Potential increases in productivity and reductions in the cost of electric furnace steel could result from continuing research efforts in continuous charging of prereduced iron ore, preheating of scrap, and higher power furnaces. An increase in the production of electric-furnace steel would increase scrap usage.

Q-BOP steelmaking: 1973 marks the second year of commercial use of the bottom oxygen blowing process (called Q-BOP by United States Steel Corporation) of steelmaking. Current existing and scheduled worldwide capacity is 17.3 million tons. The potential of the process is still being debated in the industry, but it has been estimated that very rapid growth potential exists for a worldwide capacity of over 400 million tons of Q-BOP steel by 1980. The process is an improvement over the BOF in raw materials versatility, and can accept maximum scrap charges in the range 45-60 percent. Success of the Q-BOP process could thus increase scrap usage dramatically.

Nuclear-powered steelmaking: Another development having long-range potential for ferrous scrap is nuclear-powered direct-reduction steelmaking. The Engineering Research Association of Nuclear Steelmaking, representing 13 Japanese companies and institutions, have announced plans to construct a $26 million experimental steelmaking plant which will utilize nuclear energy by 1978.[12/] The nuclear process is a direct-reduction process and would eliminate the need for coking coal, blast furnaces, and other conventional steelmaking equipment. Presumably, such a process would result in an overall reduction in the energy required to make steel, as well as, be able to accept larger scrap charges.

Estimated scrap consumption: The estimated amount and source of ferrous scrap consumed in the production of raw steel over the 1975-1990 period is summarized in Table B-1. The projections of purchased scrap consumption are based on the scrap requirements and capabilities of the various metallurgical processes expected to be in operation at various points in time.

TABLE B-1

ESTIMATED RAW STEEL PRODUCTION BY PROCESS, 1975-1990

(In millions of tons)

Year	Open Hearth	Basic Oxygen	Electric Furnace	Total
1970	48	63	20	131
1972	35	75	24	134
1975	25	85	32	142
1980	17	102	36	155
1985	9	118	43	170
1990	7	130	48	185

Source: Midwest Research Institute estimates.

In projecting scrap consumption over the 1975-1990 period, the following methodology was employed.

1. Total steel production was projected for the 1975-1990 period by extrapolating production and consumption data from 1950 to 1970, and incorporating published estimates.

2. The projected steel production was then broken down by years among the three major production processes: open-hearth, basic oxygen, and electric furnace.

3. Total scrap consumption was estimated by years, assuming scrap input to be 45 percent of total open-hearth steel production, 33 percent for the basic oxygen process, rising to 36 percent by 1990, and 100 percent for electric furnaces.

4. The scrap produced internally ("home scrap") was estimated, based on the continuation of historical trends established over the past decade, which saw the scrap produced grow from 33.5 percent in 1960 to 1970's 35.3 percent level. This proportion is expected to be at 35.5 percent in 1980 and to 36.0 percent by 1990, reflecting more in-plant custom fabrication.

5. The demand for purchased scrap was calculated as the difference between total scrap requirements (from Step 3) and internally-produced scrap (step 4). The results are summarized in Table B-2.

TABLE B-2

FERROUS SCRAP DEMAND IN RAW STEEL PRODUCTION, 1960 TO 1990
(In millions of tons)

Year	Total Raw Steel Production	Home Scrap Produced		Purchased Scrap		Total U.S.A. Scrap Demand	
		Quantity	Percent	Quantity	Percent	Quantity	Percent
1960	99.3	33.3	33.5	18.8	19.0	52.1	52.5
1965	131.5	46.7	35.5	23.1	17.6	69.8	53.1
1970	131.5	46.4	35.3	22.9	17.4	69.3	52.7
1972	133.1	47.3	35.5	22.8	17.2	70.1	52.7
1975	142.0	49.7	35.0	22.1	15.6	71.8	50.6
1980	155.0	55.0	35.5	23.4	15.1	78.4	50.6
1985	169.0	60.5	35.8	27.9	16.5	88.4	52.3
1990	184.0	66.2	36.0	31.8	17.3	98.0	53.3

Source: Annual Statistical Report, American Iron and Steel Institute; forecasts by Midwest Research Institute.

As shown in Table B-2, the domestic market for purchased scrap will decline to 22.1 million tons in 1975, then begin to rise again and will be at 31.8 million tons by 1990. These projections are based on the technical requirements (ratios) of the three principal steelmaking processes and production forecasts. The remainder of ferrous scrap demand comes from two sources: foundries and exports.

Foundry requirements are 100 percent scrap, but total demand for foundry products has not risen significantly for some time. However, certain "low spec" foundry products could accept low-grade steel scrap from municipal waste which would free higher grades for steel furnaces. Despite this potentital, we see very little movement this way; the steel industry will absorb most of the ferrous metal recovered from municipal waste.

Export tonnage has ranged between 7 and 11 million tons annually, which is a large percentage of purchased scrap demand for domestic uses. (In fact, strong export demand and some decline in prompt steel scrap production from auto plants in 1973 led to skyrocketing prices for steel scrap.) Based on the trends, export demand will rise to 16 million tons by 1990 (but it is highly volatile and could go higher or lower). Nonetheless, with worldwide demand for steel rising, we can only conclude that exports of scrap will rise and domestic demand will rise too.

The principal conclusion from our analysis of steel scrap demand trends in steel furnaces in this section is that the relatively modest recovery of ferrous scrap from municipal waste we have forecast can be readily absorbed into the principal ferrous metal cycle--steel furnaces. Exports, copper precipitation, and foundries are also potential outlets for recovered scrap, and we see no demand limitation for any scrap recovery from municipal waste--appliance metal or mixed ferrous fractions with a high metal can content.

APPENDIX C

AN OVERVIEW OF ALUMINUM INDUSTRY PRODUCTION AND SCRAP USAGE CHARACTERISTICS, 1960 to 1990

ALUMINUM INDUSTRY CHARACTERISTICS

Introduction

The aluminum industry is made up of (1) integrated primary producers and fabricators who convert bauxite into fabricated aluminum products; (2) nonintegrated aluminum producers who rely on scrap and primary and secondary aluminum ingot purchased on the open market; and (3) secondary smelters who convert scrap aluminum into secondary ingot.

The chief users of aluminum scrap are secondary smelters who use approximately 67 percent of the total scrap, followed by integrated producers (19 percent) and other producers who use 14 percent. Integrated producers generally obtain the scrap they consume from internal sources and customer scrap; smelters and nonintegrated producers buy scrap. Nearly 90 percent of secondary ingot produced by secondary smelters is consumed by nonintegrated foundries.[4/]

The aluminum industry reports scrap consumption in terms of "new scrap," "old scrap" and "sweated pig." New scrap comes in roughly three forms: borings and turnings, clippings, and slag from aluminum fabrication and converting plants. Borings and clippings result from machining operations, while clippings and slag are by-products of various melting operations that are part of the smelting and refining processes.

Old scrap, by comparison, is obtained from obsolete products that contain aluminum and is recovered by aluminum scrap dealers. Most of this type of scrap is still not, however, recovered from municipal waste streams. In almost all cases, this type of scrap is recovered from objects that are easily recoverable such as obsolete airplanes, boats, building products, and other sources. However, scrap dealers do not recover aluminum cans in significant quantity, although consumer collection centers for aluminum cans are common.

Sweated pig is a somewhat different category. This is the aluminum that is separated from iron and steel when mixed scrap is heated in ovens in which the aluminum is "sweated" from the higher melting temperature ferrous metal.

Aluminum Supply and Demand Trends

Production and consumption of aluminum increased at a high growth rate in the past. In 1961, less than 2 million tons of primary metal were produced and slightly over 2.3 million tons were consumed. In 1970, by comparison, almost 4 million tons of primary aluminum were produced and more than 5 million tons were consumed.*

The aluminum industry is now successfully marketing a broader range of products made of aluminum, and it is expected that there will be a growing demand for aluminum in the years to come.

The automobile industry, in order to produce lighter, more efficient cars is turning to aluminum engines, bumpers and bumper hinges to make a lighter automobile. The Vega now has an aluminum engine block and aluminum bumper system, and other automobile manufacturers are evaluating the benefits that a lightweight engine would afford. If auto makers continue turning toward aluminum engine blocks and other lightweight parts, it would result in a large demand increase in the aluminum industry.

Other industries are also utilizing aluminum for its lightweight and strength characteristics for applications that have advantages in a variety of products. Construction and packaging products are designed with aluminum where a lightweight metal is needed.

Since most sectors of the aluminum industry have an optimistic demand outlook, the possibility that reserves of aluminum ore will be depleted was considered to see what effect they would have on MRI's basic demand forecasts.

A report on solid waste and litter prepared by the Warton School of Finance and Commerce of the University of Pennsylvania gives the following dates at which it is expected that known world reserves of aluminum ore will be depleted:

The year 2125 - Assuming the 1965 rate of consumption, no allowance for increased population; reserves of ore are limited to mineable grades; no submerged bodies of ore are found.

The year 2030 - Assuming a 2.5 percent per year increase over the 1965 rate of consumption; no allowance for increased population; reserves of ore are limited to current mineable grades; no submerged bodies of ore are found.

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* Source: Aluminum Statistical Review, 1972.

The Wharton School report also stated the following:

> "Prospects for the supply of aluminum are excellent to at least the year 2000. On the other hand, domestic reserves of aluminum are not adequate to meet the projected demand. Thus, it must be expected that the aluminum produced in the U.S. will represent an ever smaller percentage of total U.S. consumption, increasing our dependence on overseas suppliers."

Taking these facts into consideration, we estimate that the aluminum industry's growth rate in the U.S. will slow in the 1972 to 1990 period, compared to the 1960 to 1972 levels. This is not to say that there will be no growth in the industry, but instead there will be a leveling off of primary metal demand accompanied by a significant increase in the use of secondary aluminum.

The basis of our demand forecasts are: (1) a predicted continued gain in GNP; (2) the stepped-up use of aluminum by the automobile industry, and the construction industry; (3) the growing use of mobile homes; and (4) a continued growth of the use of aluminum in packaging. MRI estimates that future primary aluminum production will increase at a rate between 4 and 5 percent per year over the 1972 to 1990 period.

This means that from the base of 4.1 million tons of primary aluminum produced in 1972, primary aluminum production will grow to 9.1 million tons by 1990 (Table C-1 and Figure C-1).

The same growth rate will also apply to total U.S. demand which is forecast to increase from 5.7 million tons in 1972, to 12.1 million tons by 1990 (Table C-1 and Figure C-1). Some detail of these forecasts follow.

Aluminum Scrap Use

The trends in scrap use for the industry are summarized in Table C-2. Here it can be seen that as an industry, the recovery of "new scrap," i.e., fabrication scrap, is by far the most important. Next in importance is the recovery of obsolete scrap ("old scrap") by secondary materials dealers who accounted for 255,000 tons of old scrap recovery in 1972; this will rise to 800,000 tons in 1990. At the same time, new scrap recovery will rise from 873,000 tons in 1972 to 2.0 millions tons in 1990.

TABLE C-1

PRIMARY ALUMINUM PRODUCTION SCRAP RECOVERY AND U.S. CONSUMPTION, 1960 to 1990

(In thousand tons)

Year	Primary Production	Net Imports	Aluminum Scrap Recovery	USA[a] Consumption
1960	2,014.5	-112.3	433.0	2,152.6
1961	1,903.7	90.7	485.0	2,385.7
1962	2,117.9	168.5	582.0	2,900.0
1963	2,312.5	227.6	654.0	3,243.8
1964	2,552.7	159.8	707.0	3,482.6
1965	2,754.5	313.2	829.0	2,989.8
1966	2,968.3	359.9	887.0	4,562.3
1967	3,269.2	186.9	878.0	4,169.0
1968	3,255.0	432.5	997.0	4,738.3
1969	3,793.0	30.9	1,150.0	5,109.0
1970	3,976.1	-132.0	1,000.0	4,600.0
1971	3,925.2	358.8	1,050.0	5,074.0
1972	4,122.4	474.2	1,173.1	5,775.8
1975	4,900.0	b/	1,401.0	6,301.0
1980	6,000.0	b/	2,005.0	8,005.0
1985	7,500.0	b/	2,630.0	10,130.0
1990	9,100.0	b/	3,300.0	12,400.0

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a/ Note: Figures may not equal total due to adjustments in government stockpiles and in industry inventories.

b/ Not Forecast

Source: U. S. Department of Commerce Business and Defense Service Administration, Containers and Packaging, 20(1):9 April 1967. Modern Packaging Encyclopedia, William C. Simms, ed., Vol. 40, No. 13A New York, McGraw Hill, Inc., September 1967, 879 p. The Aluminum Association Aluminum Statistical Review - 1972 New York, July 1973. Forecasts by Midwest Research Institute.

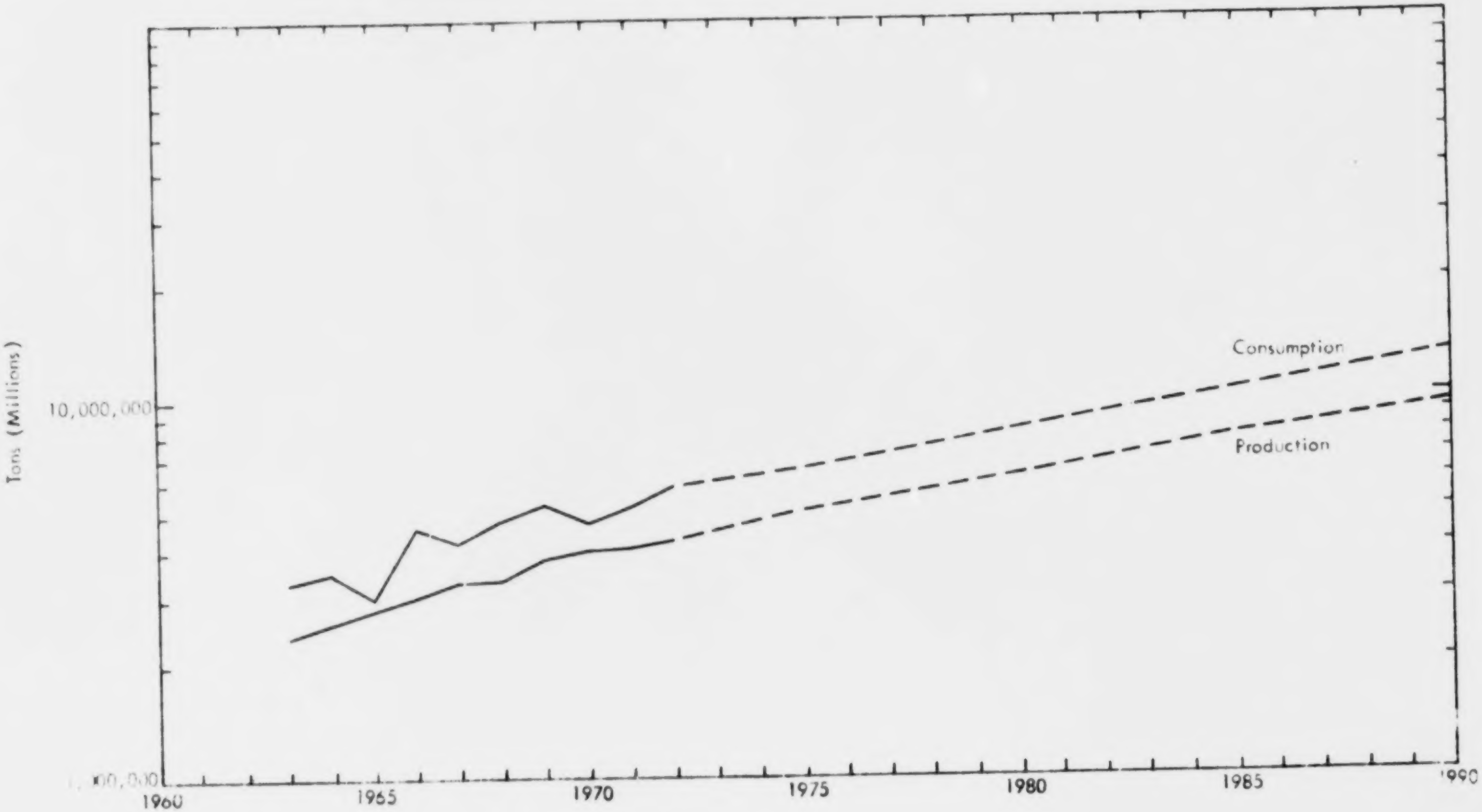

Figure C-1 - Primary Aluminum Production and U.S. Consumption

TABLE C-2

ALUMINUM INDUSTRY SCRAP RECOVERY AND SCRAP CONSUMPTION, 1960-1990

(In thousand tons)

Year	Total Metal Recovery From Scrap	From New Scrap	From Old Scrap	From Municipal Waste	Scrap Consumption[a]
1960	438	343	95	--	523
1965	829	624	205	--	970
1970	1,000	803	193	4	1,167
1972	1,155	873	255	27	1,260
1975	1,401	1,000	350	51	1,500
1980	2,005	1,400	500	105	2,110
1985	2,630	1,700	650	280	2,735
1990	3,300	2,000	790	510	3,515

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[a] Includes aluminum scrap before recovery of the net metallic content of aluminum, which upon reduction is scrap recovery in Table B-1.

Source: Aluminum Association Annual Statistical Review - 1972; Reynolds Metals Company; Forecasts by MRI.

The principal significance of the recovery of aluminum from municipal waste is that it is the integrated primary metals producers who purchase and consume this metal (as opposed to secondary smelters and foundries). Beverage cans, for example,recycle directly back into can sheet. As recovery of aluminum from municipal waste increases, the primary metals makers are likely to continue to utilize essentially all of this source. In a sense then, a completely new secondary metals market is springing up--one that is being sought by traditional scrap metals dealers, but which produces alloy metal favorable for use by primary smelters.

APPENDIX D

ANALYSIS OF PACKAGING PLASTIC RESIN DEMAND BY END USE

INTRODUCTION

There are five major end use categories in plastics packaging--film, blow molded containers, coatings, closures and caps, and miscellaneous packaging. Film and miscellaneous packaging constitute the highest quantity end uses in terms of tonnage. Film accounted for 1.4 million tons or 48 percent of total packaging resin in 1972; miscellaneous packaging (thermoformed and injection molded packages) for 0.64 million ton or 21.6 of total packaging resins in 1972. Blow molded containers were in third place in 1972 at 0.46 million ton, followed by coatings at 0.35 million ton.

In the sections that follow, an analysis of trends in each end use area is made.

BLOW MOLDED CONTAINERS

End Uses for Blow Molded Containers

Plastics are a relatively new material for the production of containers. Their light weight, safety, design versatility and attractive appearance generated a market demand for an estimated 6.73 billion containers in 1972 and demand for 458,000 tons of plastic resin.

Blow molded containers have been replacing glass containers for packaging household chemicals, toiletries and cosmetics and medicinal and health products. They have just begun to penetrate the food industry and are being test marketed for soft drinks.

The household chemical market is saturated, and little growth is projected. Medicinal, health, toiletry and cosmetic markets are growing rapidly as many firms install "in-house" blow molding equipment. Food markets will develop slowly because of the severe processing requirements for packaging food products. The soft drink container manufactured from barrier resins will begin to reach significant commercial volume by 1980, and grow rapidly to 5.0 billion containers by 1990, assuming that "restrictive" federal legislation does not inhibit the entry of plastics into beverage containers. Resin demand for containers is projected to increase at 9.1 percent per year, reaching a consumption of 920,000 tons by 1980.

Initially introduced as a "squeeze bottle" for spray deodorants and nasal sprays in 1947, plastic containers did not achieve a significant market penetration until the acceptance of the blow molded polyethylene bottle for bleach during the late 1950's. Growth increased steadily to 1.0

billion containers in 1960, as plastic bottles became accepted for packaging liquid detergents, abrasive cleaners and other cleaning compounds. The development of the clear plastic bottle in 1965, and blow molding equipment for "in house" molding, added to the growth of plastics. Toiletries, cosmetics, medicinal and health products, and milk markets all developed rapidly during the past decade to reach the current level (Table D-1).

TABLE D-1

PLASTIC BLOW MOLDED CONTAINERS
(In million units)

End Use	Quantity-No Units 1963[a]	 1972[b]
Household Chemicals	1,351	2,600
Industrial Chemicals	38	250
Toiletries and Cosmetics	416	1,380
Medicinal and Health	142	1,000
Food	22	300
Milk	--	800
Beverage	--	300
All Other	20	100
Total	1,989	6,730

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a/ U.S. Department of Commerce, Bureau of Domestic Commerce, "Containers and Packaging," Volume 25, No. 3, (October 1972), p. 18.
b/ Midwest Research Institute estimates.

Household and industrial containers: Approximately 2.85 billion plastic containers were used in 1972 to package household and industrial chemicals and specialties. This market now accounts for 41.5 percent of all plastic containers. Nearly all liquid detergents, bleach, ammonia, and powdered cleaners are packaged in plastic containers. Fabric softeners, starch and floor waxes are packaged in both plastic containers and aerosol metal cans.

Although demand has doubled since 1963, the rate of growth has been slowing since most of the conversions from glass containers have been completed. Selected insecticides and scouring powder conversions to plastic will generate a growth rate of 3.5 percent per year to a level of 3.15 billion containers in 1975. Beyond 1975, growth will slow to a rate of 2 percent per year reaching a level of 3.45 billion units by 1980.

Plastic containers are also used for agricultural, industrial and institutional chemicals and cleaning products. Many of these are larger containers that are reused in industrial and institutional chemical laboratories.

Toiletries and cosmetics: Toiletries and cosmetic products were packaged in 1.48 billion plastic containers in 1972. Plastic containers offer light weight and resistance to breakage. Since package design is very important in creating an image of the product, the flexibility of designing the container in unique shapes available in clear or colored containers has helped establish plastics in consumer markets. Hair shampoos and colors, lotions, powders, suntan oil, creams and baby oils are packaged in plastic containers.

The growth was quite rapid during the past decade, increasing from 416 million units in 1963 to 1.40 billion in 1969. Growth has been erratic since then, declining to 1.12 billion in 1970 before increasing to 1.38 billion in 1972.

Plastic containers have achieved much of their recent growth at the expense of glass containers. Many firms are installing their own equipment to blow mold containers and growth is projected at 15.2 percent per year to 1975, and 10 percent per year from 1975 to 1980. Beyond 1980, growth will slow to 5 percent per year as the market becomes saturated. Demand will reach 2.1 billion units in 1975 and 3.5 billion in 1980.

Medicinal and health: Medicinal and health products are being converted to plastics packages from glass at a slower rate than household and toiletry products. A wide variety of products such as aspirin, mouth washes, vitamins, antacids, alcohol, nasal sprays, and cremes are packaged in plastics. The impermeability of glass is still a benefit in many products and it is still the dominant packaging material.

Plastic containers increased from 142 million in 1963 to 1.0 billion in 1972, and should increase at 14.2 percent per year to 2.9 billion by 1980, as more drug firms install molding equipment to manufacture their own containers.

Food and Beverage: Food and beverages represent the largest potential market for plastic containers since over 130 billion containers are used each year in these markets. Food products alone represent a potential for 44 billion plastic containers a year.

Plastics have made a small penetration in the food industry with 300 million containers used in 1972 to package syrup, liquid margarine, vegetable oils, mustard, mayonnaise, and vinegar. The development of the new nitrile barrier resins should begin to open new markets for plastics in uses where moisture and oxygen transmission problems have prevented existing plastics from being accepted.

Demand will increase gradually to 500 million units in 1975, and 750 million by 1980. As the new barrier resins become accepted beyond 1980, demand will increase to 1.5 billion by 1990.

One of the fastest growing markets has been the containers used for packaging fluid milk. Initially introduced prior to 1963, demand rapidly increased to 800 million units, equivalent to 15 percent of the current milk packaging market. This growth was promoted through the continuing reduction of prices of polyethylene resins and the installation of blow molding equipment in the dairy plant. This has caused a rapid decline in the use of the glass container. Demand is projected to increase rapidly to 2.2 billion containers in 1980, as plastics almost completely replace glass, and also make large inroads into paper containers.

The largest potential use for plastic containers is to package part of the 86.5 billion units of beer and soft drink sold in containers. Plastic resin producers have been working to develop a resin for this market that would be clear, nearly impermeable to moisture, oxygen, and carbon dioxide transmission and still be economical and have the necessary strength when molded into a soft drink container. The nitrile "barrier" resins, which are under development and have been test marketed in soft drinks, show the greatest promise of penetrating this market. They should be fully developed and commercial by the end of the decade. Demand for plastic beverage containers will increase to 600 million by 1975, and 1.0 billion by 1980. As the barrier resins become commercial, plastic beverage container demand will increase rapidly to 5.0 billion by 1990.

Currently, about 300 million units are used to package a variety of juices and noncarbonated beverages. These are primarily polyethylene containers.

Miscellaneous containers: Other uses for plastic containers include automotive products such as antifreeze, deicers and lubricants. Demand was 100 million units in 1972, and should increase slowly to 150 million by 1980.

Plastic container use will continue to grow rapidly--from 6.73 billion units in 1972 to 9.2 billion units in 1975; 14.0 billion in 1980, and 24.6 billion in 1990 (Table D-2).

TABLE D-2

DEMAND FOR BLOW MOLDED PLASTIC CONTAINERS BY END USE, 1972 TO 1990
(In million units)

End Use Category	1972	1975	1980	1990
Household Chemicals	2,600	2,850	3,100	3,700
Industrial Chemicals	250	300	350	450
Toiletries and Cosmetics	1,380	2,100	3,500	5,700
Medicinal and Health	1,000	1,500	2,900	5,000
Food	300	500	750	1,500
Milk	800	1,200	2,200	3,000
Beverage	300	600	1,000	5,000
All Other	100	120	150	200
Total	6,730	9,170	13,950	24,550

Source: U.S. Department of Commerce BDSA; "Containers and Packaging," 1972. Midwest Research Institute Forecasts.

Resin Consumption for Blow Molded Containers

The blow molded container was originally developed from low density polyethylene which is soft and flexible. However, the rigidity and stiffness of high density polyethylene,along with its low cost,made it the choice for over 80 percent of the plastic containers manufactured in 1972. Low density polyethylene has been in limited use in the drug, cosmetic and food markets where a flexible container is desired. The bellows type container for dessert topping is an example.

Although polyethylene was rapidly accepted for household chemicals, toiletries and cosmetics and some medicinal and health products, it has not penetrated the food markets because of its lack of clarity and poor resistance to gas and water vapor transmission.

The clear PVC bottle was developed in 1965 for use in products where clarity was desired. They also had resistance to oil and oxygen and good rigidity. Numerous nonfood uses developed and although projections for rapid penetration of the food market were common, its cost limited its use. PVC received another setback recently when the FDA challenged its use for liquor containers, after laboratory tests revealed residues in the packaged liquor.

Polypropylene resins have the greatest potential use for packaging various food products. It is competitive with PVC where clarity is desired and can be filled at temperatures up to 190°F. Polypropylene will have a higher unit yield per pound of resin because of its low density and will cost less than PVC. Current demand is about 15 million pounds of resin and increasing rapidly. It is being used to package syrup and sugar based refrigerated fruit drinks.

Other resins used for blow molding include polystyrene, nitrile, and XT acrylics. Polystyrene has clarity and can be injection molded into decorative containers for nonhygroscopic powders and solids. The XT acrylics have clarity, excellent oil resistance, and can be hot filled. These are multipolymers that also have good oxygen barrier properties. The nitrile resins are a recent development and have excellent barrier resistance to oxygen, carbon dioxide and moisture transmission. Its clarity and the above properties have made it a leading contender for soft drink markets.

High density polyethylene will continue to be the preferred resin for most containers where clarity, strength, and barrier properties are not required. PVC is not expected to grow because of its higher cost and problems in the food industry. Polypropylene will increase its penetration in the food area because it offers clarity and can be filled at higher temperatures. The greatest growth will occur to the resin which is developed for the soft drink container. The current nitrile resins are the leading contenders, but newer composites may be developed that will be competitive with the nitriles.

The demand for all plastic resins used in blow molded containers increased from 97,000 tons in 1963 to 459,000 tons in 1972. Demand will nearly double to 920,000 tons in 1980, and to 1,620,000 tons in 1990 (Table D-3).

TABLE D-3

RESIN CONSUMPTION IN BLOW MOLDED CONTAINERS
(In thousand tons)

Type of resin	1963	1972	1975	1980	1990
Polyethylene HD	87	385	520	783	1,195
Polyethylene LD	10	23	30	50	100
Polyvinyl Chloride	1	35	35	35	35
All Other	--	15	25	52	290
Total	97	458	610	920	1,620

Source: Midwest Research Institute estimates based on literature and industry sources.

FLEXIBLE PACKAGING, FILM, CONVERTED WRAPS AND BAGS

End Uses for Flexible Plastic Packaging

Flexible plastics account for the greatest volume of resins used in packaging. These items are manufactured from plastic film and sheet into numerous forms of protective packaging wraps, pouches and bags.

Converted wraps: Wraps are formed by machine around a product from a roll of flexible plastic. The wraps may cover the product alone, such as a bread wrap, or may be an overwrap which covers folding cartons for decorative or promotional purposes. It may also be used to bundle a group of packages such as multipack soft drinks, or as a shrink palletizing wrap for industrial uses.

Preformed Bags: Preformed bags are manufactured in a variety of shapes. Some common uses are boil-in-bag pouches for frozen vegetables, bread, paper goods, toys, housewares, hosiery, candy, fresh meats and snack food. Most preformed plastic bags have welded sides and may have a bottom seam or gusset; they can be made with or without a lip.

Film: Most of the plastic film is used to manufacture bags and wraps for food and consumer products. Food packaging accounts for 25 percent of the film where it is used to package and wrap meat, produce and baked goods. This end use is growing at 7 percent per year and will continue at this rate through 1980.

Nonfood items packaged in plastic film include garment bags, industrial liners and bags, soft goods, shrink pallet wrap and trash bags. Trash bags are now the biggest single use for film, and have grown from an introductory product 5 years ago to a market demand of 250,000 tons per year of resin. This end use will continue to grow, although not as rapidly as in the past. Some cities and private waste haulers have "institutionalized" demand for garbage sacks by requiring their use for pickup from households.

One possible new growth market for plastic film is the polyethylene grocery sack, which is being test marketed against the kraft paper sack. A moderate growth is projected, although some sources feel it will grow rapidly. Other industry experts feel it has no significant future in competition with paper sacks and will never gain popularity with consumers.

Flexible films and bags manufactured from plastics compete with paper and aluminum. In many cases, combinations of these materials are used in the form of laminates. The plastic materials have been increasing their share of this market and are now the largest volume of the three.

Sales of these products for 1960 and 1972 indicate the rate at which plastics have increased their share of the market (Table D-4).

TABLE D-4

DEMAND FOR FLEXIBLE PACKAGING MATERIALS IN PACKAGING, 1960 AND 1972
(In millions of dollars)

Packaging Category	1960		1972	
	Amount	Percent	Amount	Percent
Paper	$352	42.3	$492	27.9
Cellophane	277	33.3	250	14.2
Polyethylene	140	16.8	770	43.7
Other Plastics			170	9.6
Metal Foil	63	7.6	82	4.6
Total	$832	100.0	$1,764	100.0

Source: Modern Plastics Encylcopedia, 1972.

Plastic materials have increased their share of this market from 16.8 percent in 1960 to 54.6 percent in 1972. They have essentially captured most of the growth in flexible packaging materials.

Resin consumption for flexible packaging uses: It is estimated that 1.4 million tons of plastics and cellophane were used in 1972 for flexible packaging. The largest single resin in use is low density polyethylene, because it is the lowest cost transparent packaging material, has outstanding chemical and barrier properties, and in many applications can compete with paper economically. It is estimated that 1.1 million tons of LD polyethylene were used for packaging in 1972. Other films include cellophane, polyvinyl chloride and polypropylene (Table D-5).

TABLE D-5

FLEXIBLE PACKAGING RESIN DEMAND BY TYPE, 1968 TO 1980

(In thousand tons)

Type of Resin	1968	1972	1975	1980
Polyethylene LD	477	1,067	1,362	1,870
Polyethylene HD	72	24	35	75
Cellophane	180	163	145	125
Polyvinyl Chloride	45	67	100	150
Polypropylene	33	50	83	125
Others	45	45	75	110
Total	792	1,416	1,800	2,555

Source: Modern Plastics, 1968-1972; MRI estimates, 1975-1980.

The demand for all films has nearly doubled since 1968, and a significant amount of the growth has come from the polyethylene trash bag. Other film uses such as pallet wrap, garment bags, and rack and counter films have also grown rapidly.

Flexible films are projected to increase at 7.5 percent per year from 1.4 million tons in 1972 to 2.6 million tons by 1980, as trash bags, grocery bags and pallet wrap markets continue to develop (Table D-5).

Low Density Polyethylene

As indicated in Table D-5, low density polyethylene is the most popular resin used for packaging wraps and bags. It is commonly used to wrap produce, meat, poultry and baked goods. It also finds application as bags for dry cleaned garments, industrial bags and liners, household wrap, pallet wrap and trash bags. Estimated LD polyethylene resin consumption by end use is also given (Table D-6).

Demand for LD polyethylene is expected to continue to increase at 8 percent per year to reach 1.9 million tons by 1980. The greatest growth will be in shrink packaging primarily for industrial pallet wrap and consumer beverages. Food uses will continue to grow as new applications are developed and cellophane is replaced.

High density polyethylene: High density polyethylene has had only limited use as a packaging film. About 24,000 tons of HD polyethylene were consumed in 1972, primarily for packaging snack foods and for wraps to cover carpets during their shipment from the mills.

TAPLE B-6

LOW DENSITY POLYETHYLENE CONSUMPTION IN FILM APPLICATIONS, 1968 - 1980
(In thousand tons)

Market Category	1968	1972	1975	1980
Food				
Baked Goods	63	100	135	180
Candy	7	15	20	30
Frozen Food	15	23	35	50
Meat and Poultry	15	19	25	35
Produce	85	113	130	170
Miscellaneous Food	30	30	37	55
Total Food	215	300	382	520
Nonfood and Bags				
Garment Bags	37	60	70	80
Industrial Liners and Bags	55	57	60	70
Rack and Counter	25	66	80	100
Soft Goods	35	59	80	100
Household Wrap and Bags	40	30	30	30
Shrink Pallet Wrap	--	55	75	175
Trash Bags	--	250	350	450
Miscellaneous Packaging	70	190	235	345
Total Nonfood	262	767	980	1,350
Total LDPE	477	1,067	1,362	1,870

Source: Modern Plastics, 1968-1972; MRI estimates, 1975-1980.

The future growth for HDPE will depend upon the rate of replacement of paper for grocery bags. Currently, it is limited to specialty paper markets such as nontarnish and lint-free tissue paper, florist wrap, delicatessen wrap and other selected wax paper markets.

Perhaps the most promising new endure for HDPE is the grocery bag. Although problems exist in fabricating polyethylene in existing equipment, at least 250 million bags per year are being used by IGA Foods.[27] If 20 percent of this market were to convert to HDPE, it could mean an additional 90,000 tons of resin per year. Its success will depend upon the future costs of paper relative to HDPE. Presently, paper is still the lowest cost product. HDPE should continue to slowly penetrate this market, reaching a level of 75,000 tons by 1980.

Polyvinyl chloride: PVC packaging films are estimated at 67,000 tons per year. Its most popular market is wrapping for fresh meats and produce. PVC is increasingly being used as a shrink film for carton wraps where good visibility, combined with strength, are desired.

PVC has been widely accepted for meat packaging because it is soft, resiliant and nonfogging. It also permits oxygen transmission which maintains the color of the meat to make it more appealing to customers. PVC is expected to continue its growth, reaching 100,000 tons by 1975, and 150,000 tons by 1980. However, FDA officials have expressed concern about potential migration of chemical compounds into meat and the use of PVC could be restricted for meat packaging.

Polypropylene: Polypropylene film amounted to 50,000 tons of resin in 1972, primarily in food packaging.

Polypropylene film competes with polyethylene or cellophane, depending upon the manufacturing process. The cast film competes with polyethylene, while the oriented film competes with cellophane. Most of the current markets are for the oriented film where it is most often used as a lamination with cellophane, glassine, polyethylene, paper or aluminum foil.

Much of the growth in use of polypropylene film will come at the expense of cellophane and paper. The tobacco industry, which represents about 22,000 tons of cellophane, is expected to be completely converted to polypropylene by 1978. Other potential developing markets include baked goods, candy and meats.

The future for polypropylene looks bright as its relative cost to polyethylene begins to narrow. Estimates of demand as high as 420,000 tons by 1980 have been projected; and if this demand develops, most of the volume would be at the expense of polyethylene. MRI estimates 224,000 tons use by 1980 as a realistic forecast for polypropylene.

Other resins: Other resins include polystyrene, nylon, polyvinylidene chloride, and coextrusions. Of all of these the latter is showing the greatest growth. This is a new technology where two or more different films are extruded together to form a composite film. These films combine the attractive properties of both resins to solve specific packaging problems. An example is the use of coextruded LD and HD polyethylene for snack foods. Demand for these resins amounted to 45,000 tons in 1972, and should increase to 110,000 tons by 1980.

Cellophane is the second largest volume packaging film next to low density polyethylene. Demand has been declining as the polyolefins have replaced it in many food markets. Consumption in 1966 of 197,000 tons has declined to 160,000 tons in 1972, and will continue to drop to 125,000 tons by 1980.

Most of the decline in the use of cellophane has been in baked goods and meat where the plastic films have made their greatest penetration. Cigarette film has declined slightly and will decline further as polypropylene replace it (Table D-7).

TABLE D-7

CELLOPHANE DEMAND BY END USE, 1966 - 1980
(In thousand tons)

End Use	1966	1972	1975	1980
Baked Goods	39	24	20	15
Meat	30	7	5	5
Tobacco	30	26	15	0
Snacks and Cookies	30	41	45	45
Candy	15	16	15	15
Other Foods	33	30	30	30
Nonfoods	20	16	15	15
	197	160	145	125

Source: Modern Packaging Encyclopedia (1966 and 1972), Midwest Research Institute (1975 and 1980).

Cellophane will continue to be used in numerous applications. It is now nearly all coated or laminated for moisture proofness and heat sealing. Saran-copolymer coated cellophane is used for cigarettes, and laminations have been developed for cookies and other foods.

MISCELLANEOUS PLASTICS PACKAGING

A wide variety of miscellaneous packaging and disposable items are manufactured from plastic resins and sheet by thermoforming and injection molding. Products such as disposable cups and tumblers; collapsible tubes; molded boxes to package cosmetics, jewelry and hardware; meat trays; egg cartons; jars and tubs for food products; foamed shipping pads; pallets and beverage cartons; and blister packaging are included in this category.

These uses accounted for 641,000 tons of resins in 1972, with polystyrene accounting for 55 percent of the total (Table D-8).

TABLE D-8

THERMOFORMED AND INJECTION MOLDED PLASTICS DEMAND BY RESIN TYPE, 1968 TO 1980
(In thousand tons)

Type of Resin	1968	1972	1975	1980
Polystyrene	250	370	470	788
Polyethylene HD	57	110	145	235
Polyethylene LD		72	95	155
Polyvinyl Chloride		40	50	75
Polypropylene		36	50	75
Cellulose	8	13	15	20
Total	315	641	825	1,348

Source: Modern Plastics, 1968-1972; MRI estimates, 1975-1980

Growth of these products has been quite rapid in the past few years, with resin consumption more than doubling since 1968. The growth is projected to increase at 9.2 percent per year through 1980, to 1.3 million tons because of the continued growth of existing markets and the development of new uses.

Polystyrene: Polystyrene is the largest volume resin used in miscellaneous packaging since it is available in a wide range of properties.

The two major types of polystyrene used in packaging are general purpose or crystal resins and impact resins. General purpose polystyrene is transparent, has a good surface gloss and optical clarity, but is brittle. Impact polystyrene is a rubber modified polymer with good energy absorption properties.

These resins are injection molded into boxes, trays, tubs, cups, lids and vials, or extruded into sheet and thermoformed into meat trays, thin walled opaque containers and single service dinnerware.

Polystyrene is also available as an expandable foam which is manufactured by heating polymer beads with a blowing agent to produce cellular beads, which have excellent heat resistance. The beads are molded into cups, boxes, trays and packaging inserts, or are formed into boards which are cut or stamped into trays and other packaging forms. It is also made into a foamed sheet and thermoformed into meat trays, egg cartons and other food packages. It is estimated the 180,000 tons of foamed polystyrene were used in packaging in 1972.

Polystyrene has been growing at 10.3 percent per year since 1968, and should reach a volume of 788,000 tons by 1980. This is equivalent to a growth of 6.7 percent per year. Demand for single service dinnerware will account for much of this growth.

Polyethylene: Polyethylene is the next largest resin with 110,000 tons of high density and 72,000 tons of low density being consumed in 1972. Products include jars, tubs and boxes and squeeze tubes. Polyethylene lacks the clarity of polystyrene, but is more resistant to chemical attack and impact, has better barrier properties and stands up well at low temperatures.

All of the low density polyethylene and about two-thirds of the high density polyethylene is used to manufacture injection molded containers. Major uses include beverage cases, pallets, snap-on reclosure lids for canned foods and coffee, squeeze tubes, vials, and a wide variety of other containers for foods and drugs.

About 30,000 tons per year of high density polyethylene is thermoformed into food containers, medical packages and blister packaging for numerous consumer products.

The other resins used for miscellaneous plastics packaging include polyvinyl chloride, polypropylene and cellulosics. PVC finds its greatest use in blister packaging, where the sheet is formed on cardboard or other backing to provide visibility for consumer products.

Polypropylene is used to manufacture drinking straws and hinged lid boxes where the hinge is an integral part of the container. Cellulosics find their greatest use in fabrication of vials and in blister packages.

PLASTIC COATINGS

Approximately 350,000 tons of resin were used in 1972 to coat polymer films, paper, paperboard, foil and cellophane. These thin coatings give the substrate moisture resistance, heat sealability, processability and resistance to oil and grease penetration at a cost less than other forms of packaging.

Low density polyethylene dominates this market with 225,000 tons consumed in 1972. It is one of the cheapest polymeric coatings that provides the desired properties. LD polyethylene is used extensively in coating milk cartons and other applications (Table D-9).

TABLE D-9

LOW DENSITY POLYETHYLENE EXTRUSION COATINGS BY END USE, 1966 - 1972
(In thousand tons)

End Use Category	1966	1972
Paper		
Multiwalls	9.2	7.5
All Other	24.0	34.0
Total Paper	33.2	41.5
Paperboard		
Milk Cartons	74.8	114.0
All Other	12.9	21.0
Total Paperboard	87.7	135.0
Films	16.0	18.5
Foil		
Food	7.6	18.0
Nonfood	7.0	11.0
Total Foil	14.6	39.0
Total Coatings	151.5	224.0

Source: Modern Packaging Encyclopedia.

The only other resins which have achieved significant use in coatings are the ethylene vinyl acetate copolymers, with a volume of 35,000 tons in 1972. These copolymers are tougher, softer, more flexible and less heat resistant than LDPE. They are applied as an extrusion coating or used as wax additives in hot melt coatings.

Other resins include PVC, HDPE, polyvinyl acetate, cellulose nitrate and polyesters which are used for coating metal cans, glass containers, cellophane and other containers.

Coatings are not projected to grow because of replacement of the milk carton by the blow molded polyethylene containers. Current demand of 114,000 tons of LDPE for milk cartons could decline to as low as 37,500 tons by 1980. This loss will be offset by growth in existing markets and new markets. One of the newer uses is the coating of glass containers to reduce breakage. Although these are thin films, there are a large number of beverage containers which can be coated.

Demand in 1980 should be about 350,000 tons of plastic resins. A tabulation by type of resin is shown in Table D-10.

TABLE D-10

COATING RESIN CONSUMPTION BY TYPE OF RESIN, 1968 - 1980
(In Thousand Tons)

Type of Resin	1968	1972	1980
Polyethylene LD	175	224	180
Polyethylene HD		18	40
Ethylene Vinyl Acetate	20	35	60
Polyvinyl Chloride	10	9	10
Others	45	44	60
Total	265	348	350

Source: Midwest Research Institute.

Caps and Closures

Closures and caps for sealing and closing rigid glass, metal and plastic containers amount to 90 billion units per year. Of this, plastic caps and closures were 12.9 billion units, requiring 95,000 tons of resin. Plastics have been growing at 4.2 percent per year since 1963. Most of these caps or closures are used on glass and plastic containers. The future growth of plastic containers will cause demand for closures and caps to increase to 23 billion units by 1980, requiring 126,000 tons of resins.

There has been a constant upgrading of closures which are now designed with dispensing units which include snip-off tops, push-pull sprays, turrets, spouts, daubers, applicators, pumps and measured dose dispensers. The flexibility of plastics has permitted the development of these devices, and will continue to allow plastics to capture markets from metal closures.

Closures and caps are made from numerous resins both thermosetting and thermoplastics. About 18 percent are the thermosetting resins such as phenolics and urea formaldehyde. Because they are rigid, they have limited design capability. Their excellent dimensional stability and outstanding chemical resistance make them desirable for many drug, pharmaceutical and chemical containers. Overall growth has been negative, and future use will be limited to those markets where the above properties are desired. About 17,500 tons of resin were used in 1972, and this will decline to 15,000 tons by 1980.

Thermoplastic caps and closures are made primarily from high density polyethylene and from polypropylene. Polystyrene, low density polyethylene and polyvinyl chloride are used to a lesser extent. Freedom of design and the ability to mold complex shapes will result in all of the future growth in closures and caps in thermoplastics. Demand for 87,000 tons of resin in 1972 will increase to 111,000 tons by 1980 (Table D-11).

TABLE D-11

RESIN DEMAND FOR CAPS AND CLOSURES, BY TYPE OF RESIN, 1972 TO 1980
(In million pounds)

Type of Resin	1972	1980
Thermoplastics		
Polyethylene HD	22.5	32.0
Polyethylene LD	9.5	14.0
Polypropylene	22.5	32.0
Polyvinyl Chloride	9.0	13.0
Polystyrene	23.5	20.0
Total	87.0	111.0
Thermosets		
Phenolics	10.0	8.0
Urea Formaldehyde	7.5	7.0
Total	17.5	15.0
Total All Resins	94.5	126.0

Source: Modern Plastics, 1972; MRI estimate, 1980.

APPENDIX E

BACKGROUND DATA FOR PAPER RECOVERY FORECASTS, 1972-1990

RAW MATERIALS PROFILE FOR THE PAPER INDUSTRY

It is significant to note that the return of recycling will be accompanied by a general decline in the importance of virgin fiber derived from the forest as roundwood (trees cut to be used as pulpwood) and from residues (which are derived from forests or wood product manufacturing operations).

All three major sources of fiber used as raw materials in domestic paper mills will increase from 1972 to 1990 as total demand for paper products increases (Table E-1, Figure E-1). However, by 1990 the profile of raw materials will shift significantly to recycled and "reclaimed" fiber: roundwood, 42.4 percent; wood residues, 31.5 percent; waste paper, 25.1 percent (Table E-2, Figure E-2). This is compared to: roundwood, 49.8 percent; wood residue 27.3 percent; waste paper, 21.4 percent in 1972. Wood residues use might increase even more than indicated if the trend to using smaller and smaller trees to produce dimension lumber continues strongly. In a sense, the whole paper industry derives about one-half its fiber from "secondary sources" in the "hierachy" of fibrous raw materials allocation in the paper industry. To the extent these fibers come from waste paper, they represent a net removal from total paper waste generation.

DEMAND FORECAST FOR RECYCLED NEWSPRINT, 1973 TO 1985

Introduction

We have forecast that news use in recycled newsprint will increase from 490,000 tons in 1973 to 1,030,000 tons in 1985. This is a 110 percent increase in recycling and will represent 22 percent of domestic newsprint production in 1985, compared to 14.4 percent in 1973.

The original three mills of Garden State Paper Company remain as the only self-standing recycling newsprint mills in the USA. However, two of these mills have been greatly expanded in capacity (Pomona, California, and Garfield, New Jersey), the latter mill having just added an estimated 80,000 tons per year capacity. In addition, Southwest Forest Industries have a news deinking plant under construction at Snowflake, Arizona, for supplemental furnish for groundwood pulp. Various other companies are reported to be considering construction of new mills (some of which have been reported in the trade press and some of which have not).

At the same time, domestic newsprint capacity is scheduled to increase by 328,000 tons per year between 1973 and 1977 to 3,925,000 tons

TABLE E-1

FIBROUS RAW MATERIALS USED IN PAPER AND PAPERBOARD MANUFACTURE
(In thousand tons)

Year	Roundwood[a]	Wood Residue	Waste Paper	Other Fibers	Total Fibrous Materials	Total Production	Ratio Fiber To Production
1950	15,518	991	7,956	1,439	25,904	24,375	1.063
1951	16,673	1,064	9,071	1,457	28,265	26,047	1.085
1952	16,076	1,210	7,881	1,211	26,378	24,418	1.080
1953	17,376	1,308	8,531	1,255	28,469	26,605	1.070
1954	17,470	1,519	7,857	1,200	28,045	26,876	1.043
1955	19,737	1,716	9,041	1,340	31,835	30,178	1.055
1956	20,699	2,300	8,836	1,551	33,386	31,441	1.062
1957	19,764	2,695	8,493	1,105	32,058	30,666	1.045
1958	19,335	3,148	8,671	1,003	32,157	30,823	1.043
1959	21,131	4,025	9,414	979	35,549	34,014	1.045
1960	21,331	4,369	9,032	971	35,703	34,444	1.037
1961	20,973	5,710	9,018	894	36,595	35,749	1.024
1962	21,678	6,921	9,075	963	38,636	37,541	1.029
1963	22,514	7,706	9,613	1,285	41,117	39,230	1.048
1964	23,905	8,182	9,843	929	42,860	41,703	1.028
1965	25,369	8,638	10,231	879	45,116	44,080	1.024
1966	26,879	10,043	10,564	980	48,466	47,113	1.029
1967	25,794	11,200	9,888	836	47,718	46,926	1.017
1968	28,705	12,598	10,222[b]	905	52,430	51,245	1.023
1969	30,415	13,285	11,969[c]	878	56,547	54,187	1.044
1970	30,710	12,482	12,021	828	56,041	53,516	1.047
1971	29,844	14,304	12,323	875	57,346	55,086	1.041
1972	30,526	16,800	13,132	892	61,350	59,457	1.032
1973[d]	30,490	18,372	14,319	964	64,145	61,833	1.037
1975	29,620	19,015	14,160	1,000	63,795	61,460	1.038
1980	34,010	24,130	17,860	1,000	77,000	74,040	1.040
1985	39,510	29,210	22,465	1,000	92,185	88,215	1.045
1990	46,370	34,280	27,340	1,000	108,990	103,800	1.050

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[a] Based on American Pulpwood Association data; 1950 to 1959 are estimates by Midwest Research Institute; 1972 to 1975 American Paper Institute: 1980-1990 MRI.

[b] Last Year for use of Bureau of Census data for waste paper.

[c] American Paper Institute data 1969 to 1975; excludes molded pulp and exports.

[d] Preliminary.

Source: "Wood Pulp Statistics--35th Edition," Pulp Division, American Paper Institute, November 1971; "The Statistics of Paper, 1973," American Paper Institute; American Pulpwood Association. Midwest Research Institute.

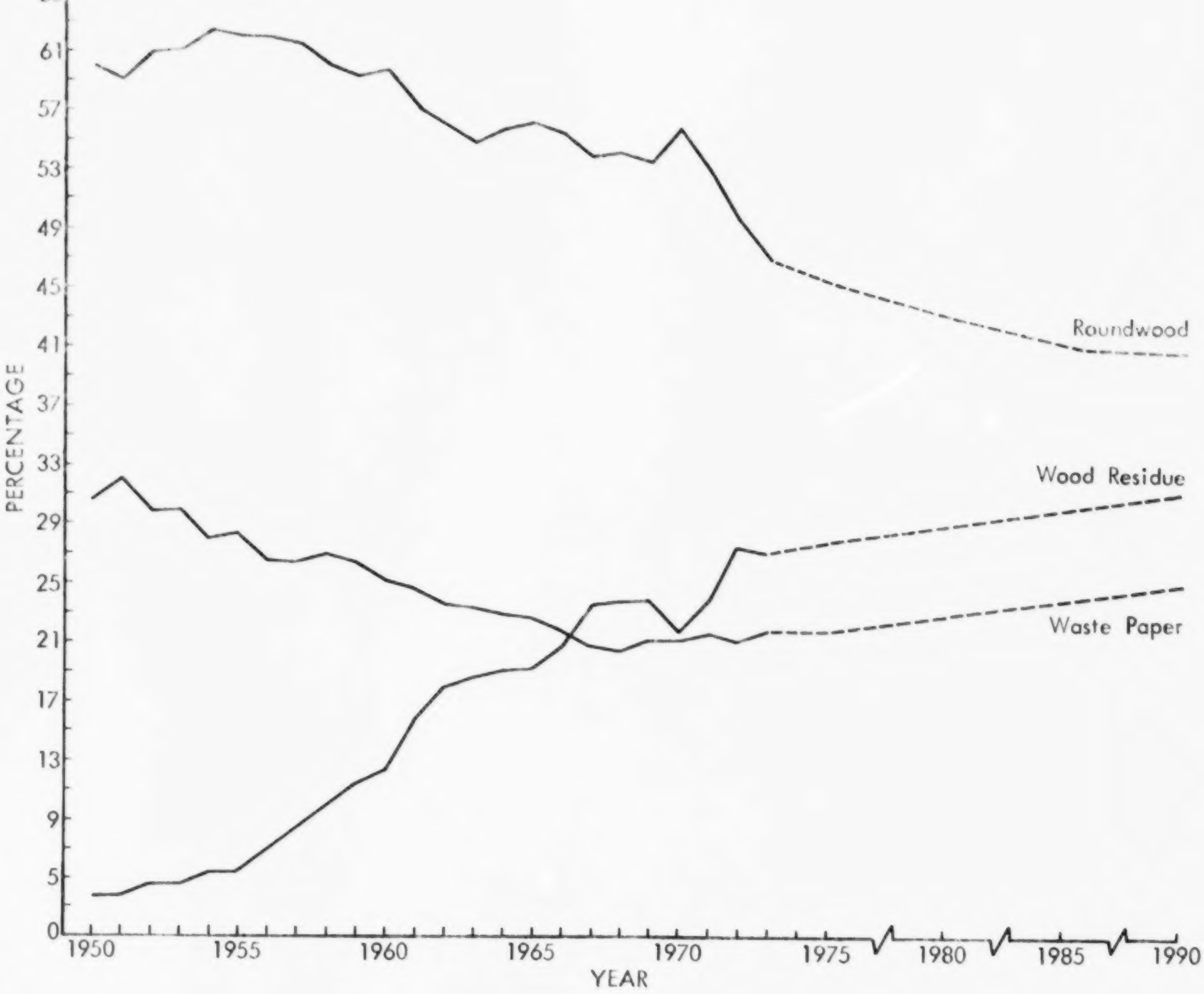

Figure E-1 - Percentage of Fibrous Raw Materials Used in Paper and Paperboard Manufacture

TABLE E-2

FIBROUS RAW MATERIALS USED IN PAPER AND PAPERBOARD MANUFACTURE
(Percentage)

Year	Roundwood[a]	Wood Residue[a]	Waste Paper	Other Fibers	Total Fibers
1950	59.9	3.8	30.7	5.6	100.0
1951	59.0	3.8	32.1	5.1	100.0
1952	60.9	4.6	29.9	4.6	100.0
1953	61.0	4.6	30.0	4.4	100.0
1954	62.3	5.4	28.0	4.3	100.0
19555	62.0	5.4	28.4	4.2	100.0
1956	62.0	6.9	26.5	4.6	100.0
1957	61.6	8.4	26.5	3.5	100.0
1958	60.1	9.8	27.0	3.1	100.0
1959	59.4	11.3	26.5	2.8	100.0
1960	59.8	12.2	25.3	2.7	100.0
1961	57.3	15.6	24.6	2.5	100.0
1962	56.1	17.9	23.5	2.5	100.0
1963	54.8	18.7	23.4	3.1	100.0
1964	55.8	19.1	23.0	2.2	100.0
1965	56.2	19.2	22.9	2.0	100.0
1966	55.5	20.7	21.8	2.0	100.0
1967	54.1	23.5	20.7	1.9	100.0
1968	54.8	24.0	19.5[b]	1.7	100.0
1969	53.7	23.5	21.2[c]	1.6	100.0
1970	54.8	22.3	21.5	1.5	100.0
1971	52.0	25.0	21.5	1.5	100.0
1972	49.8	27.3	21.4	1.7	100.0
1973[d]	47.6	28.6	22.3	1.5	100.0
1975	46.4	29.8	22.2	1.6	100.0
1980	44.2	31.3	23.2	1.3	100.0
1985	42.8	31.7	24.4	1.1	100.0
1990	42.4	31.5	25.1	1.0	100.0

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[a] Based on American Pulpwood Association data; 1950-1959 are estimated by MRI; 1972 to 1975. American Paper Institute; 1980-1990, MRI.

[b] Last year for use of Bureau of Census data for waste paper.

[c] American Paper Institute data, 1969 to 1975.

[d] Preliminary.

Source: Calculated by Midwest Research Institute.

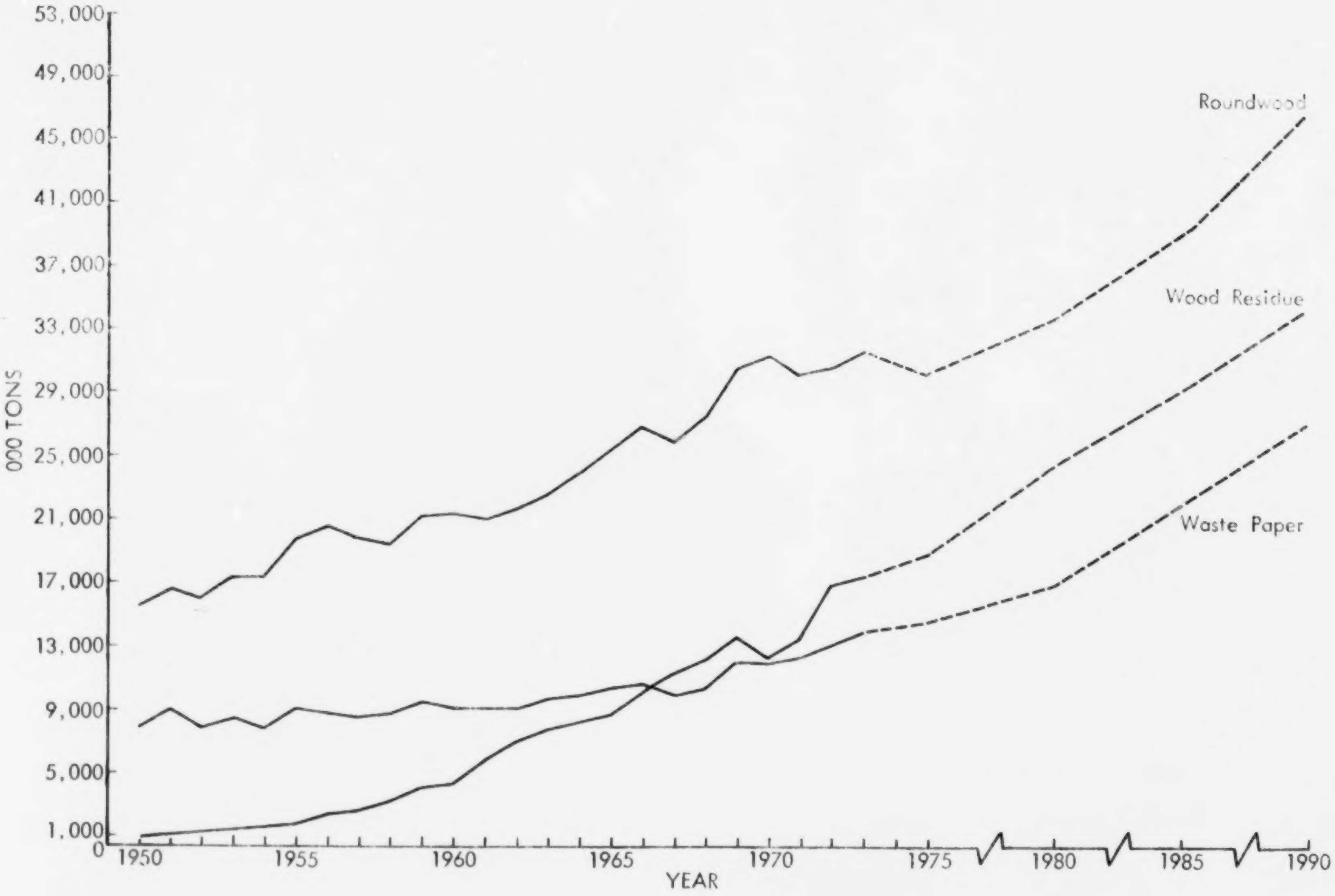

Figure E-2 - Fibrous Raw Materials Used in Paper and Paperboard Manufacture per year (9 percent); these figures include recycled news.* On a comparative basis, the use of news in deinked newsprint will rise by 47,000 tons per year between 1973 and 1976, or 10 percent.

Methodology and Demand Forecasts

Our approach to the newsprint demand forecasts was straight forward. The initial step was to make a forecast of total newsprint demand (including imports) to 1985, based on historical trends and recent patterns of demand. Although many newspaper publishers are switching to 28-pound paper, this transition should be complete in the next few years. The historic demand increase was at a rate of 3.6 percent from 1963 to 1973; 1974 and 1975 demand is expected to be down slightly from 1973's historic high. The rate of demand increase is forecast to be 2.3 percent between 1975 and 1985, putting total USA demand at 13,530 tons in 1985 compared to 10,530 tons in 1975 (Table E-3).

The next step was to determine what proportion of total demand will be satisfied by domestic mills. Domestic production has varied between 32 and 34 percent of demand since 1970, and is expected to decline to about 30 percent by 1975. Then it will increase to 32.7 percent in 1980 and 35.3 percent in 1985, returning to somewhat above the level of the early 1970's (the long-term trend is for domestic production to increase more rapidly than imports).

Based on these forecast production ratios, the domestic production will be 4,700,000 tons in 1985, compared to 3,413,000 in 1973, up 1,287,000 tons or 38 percent (See Table E-3 and Figure E-3).

Forecast for Recycled Newsprint

The third step of the procedure was to develop a forecast for recycled newsprint as a portion of domestic production. On a historical basis, the use of waste paper (news) in newsprint has grown from 11.4 percent in 1969 to 14.4 in 1973 and 16.6 in 1975 (based on the API fiber use data and our production forecast). Based on the trends taking place, we have forecast that waste paper use in news will be 22 percent of domestic production in 1985 (Figure E-3).

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* "Capacity 1973-1976: Paper, Paperboard, Wood Pulp," API, 1974.

TABLE E-3

NEWSPRINT DEMAND, PRODUCTION AND RECYCLING FORECAST, 1963 TO 1985
(In 1,000 Tons and Percent)

Year	Total Demand	Net Imports	Domestic Production	Waste Paper Use in Production			Waste Paper--Percent					
							To Demand			To Production		
				High	Actual	Low	High	Actual	Low	High	Actual	Low
1963	7,508	5,295	2,213		NA			NA			NA	
1964	8,086	5,837	2,249		NA			NA			NA	
1965	8,418	6,238	2,180		NA			NA			NA	
1966	9,239	6,892	2,347		NA			NA			NA	
1967	9,108	6,509	2,599		NA			NA			NA	
1968	9,289	6,333	2,956		NA			NA			NA	
1969	9,915	6,663	3,252		372			3.8			11.4	
1970	9,836	6,491	3,345		371			3.8			11.1	
1971	10,036	6,715	3,321		393			3.9			11.8	
1972	10,406	6,955	3,451		427			4.1			12.4	
1973	10,726	7,313	3,413		490			4.6			14.4	
1975	10,530	7,230	3,200		537			5.1			16.6	
1980	11,900	8,000	3,900	860		750	7.2		6.3	22.0		19.2
1985	13,300	8,600	4,700	1,500		1,030	11.3		7.7	31.9		22.0
Difference 1973-1985	2,574	1,287	1,287	1,010		540	6.7		3.1	17.5		7.6

Note: The forecast increase in use of waste paper in newsprint is 540,000 tons between 1973 and 1985. This is equivalent to five new deinking mills of 110,000 tons per year input capacity.

Source: "Statistics of Paper and Paperboard, 1974," API; "Capacity Surveys," API; Forecasts by Midwest Research Institute.

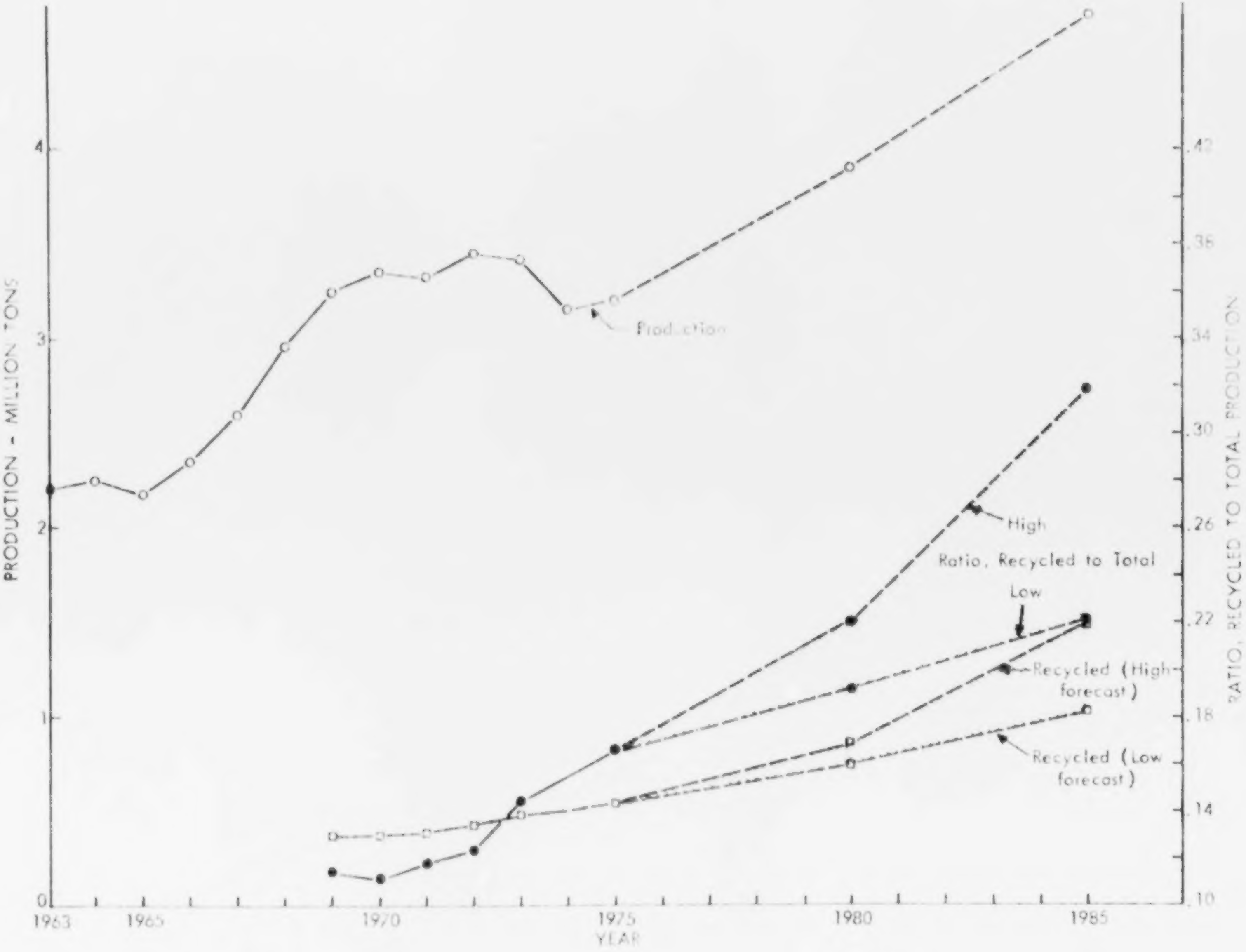

Figure E-1 - Domestic Newsprint Production, 1963 to 1985

An alternate forecast of news recycling was also made to which deinked news would capture about 80 percent of the increase in domestic production between 1973 and 1985. This would put waste paper use in newsprint at 31.9 percent of domestic production in 1985. This, then, is the high recycling forecast.

Analysis of Recycling Forecast

The recycling of news into newsprint will be at least 1,030,000 tons in 1985, compared to 490,000 tons in 1973.* Thus, our low forecast is for a doubling production of recycled news while total production increases by only 38 percent. This forecast was examined to see how reasonable it was in light of the history and outlook for newsprint production in domestic mills.

The total increase in domestic production is 1,300,000 tons in 12 years; of this, 540,000 tons (41.5 percent) would be recycled news. The 540,000 tons increase in the use of recycled newsprint would be equivalent to five new deinking mills of 110,000 tons per year input and 100,000 tons per year production.

Under the more optimistic recycling forecast, the increase in domestic production remains at 1,300,000 tons in 12 years; of this, 1,010,000 tons (or 78 percent) would be recycled news. The 1 million ton increase in the use of recycled newsprint would be equivalent to 9.2 new deinking mills of 110,000 tons per year input and 100,000 tons per year production.

In light of the trend to recycled newsprint in domestic mills, we believe this range to be a reasonable forecast. However, it does mean preferential expansion and construction of recycling capacity vis-a-vis historical ratios of recycled versus virgin fiber newsprint. On the other hand, several factors lend support to the forecast that five to nine new recycling mills could be built in the next 10 years (one every 1 to 2 years).

- * There are at least 15 major metropolitan areas that would support a recycling mill of 100,000 TPY.
- * The unrecovered supply and recoverability of news is adequate to supply these mills.

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* Note that this is input tonnage and not deinked newsprint production, which would be about 90 percent of input tonnage to allow for yield losses of waste paper.

- The long-term price of news is still in the range of $25 to $35 per ton ("super sorted").

- The capital requirements are rising, but less than for new virgin fiber capacity (per ton of capacity).

- Pollution control requirements are manageable by self-treatment or municipal sewage charges.

- Newspapers continue to express interest in purchase of recycled newsprint, recycling is favorably viewed.

- Several paper producers are making or have made mill feasibility studies.

- The price of newsprint continues to rise.

The major uncertainties are: return on investment of private capital, availability of investment funds, the uncertainties and costs of pollution control requirements, the marketability of the product (ability to tie down contracts).

On balance, we believe the forecast range for recycled newsprint is reasonable. We believe that the most probable case is that the capacity equivalent of seven new mills will be added in the next 10 years.

RECYCLING IN LINERBOARD, 1973 TO 1985

Overview

Linerboard is the predominant grade of paperboard. There are two types of linerboard--kraft liner and recycled liner. The former is at least 80 percent virgin fiber; recycled linerboard is generally all recycled fiber, but may contain up to 80 percent virgin pulp. Recycling in linerboard has only recently become significant as waste paper use in kraft linerboard has increased as well as recycled linerboard after years of decline.

The use of waste paper (principally old corrugated containers) in linerboard will increase from 759,000 tons in 1973 to 4.01 million tons in 1985, or up over 400 percent in 12 years (Table E-4, Figure E-4). This increase will be split between supplemental furnish (2.1 million tons in 1985) and recycled paperboard (1.9 million tons in 1985). At this point, waste paper input will constitute 22.8 percent of linerboard production, up from only 6.7 percent in 1973.

TABLE E-4

LINERBOARD PRODUCTION, DOMESTIC USE, 1963 TO 1985
(In 1,000 tons and percent)

(1) Year	(2) Total	(3) Kraft Liner	(4) Percent Waste Paper in Kraft	(5) Recycled Linerboard	(6) Percent Recycled To Total Liner	(7) Calculated Waste Paper Use-- In Kraft Liner					(8) Calculated Waste Paper Use-- In Recycled Liner				
						Total	Mixed	News	Container	High Grades	Total	Mixed	News	Container	High Grades
1963	6,414	5,737	NA	677	10.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1964	6,908	6,215	NA	693	10.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1965	7,481	6,731	NA	750	10.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1966	8,347	7,580	NA	767	9.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1967	8,216	7,718	NA	498	6.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1968	9,044	8,637	NA	407	4.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1969	9,692	9,345	2.6	347	3.6	259	22	0	210	27	436	36	0	382	17
1970	9,403	9,133	3.0	270	2.9	285	48	0	162	67	292	23	0	257	12
1971	9,531	9,249	2.5	282	3.0	235	15	0	149	71	305	24	0	268	13
1972	10,857	10,578	2.7	279	2.6	291	41	0	213	37	300	24	0	264	12
1973	11,356	11,067	4.0	289	2.5	449	50	1	355	44	310	25	0	273	12
1974(p)	11,146	10,791	5.3	356	3.2	594	60	0	475	59	385	31	0	339	15
1975	11,145	10,790	6.2	355	3.2	688	70	0	550	68	383	31	0	337	15
1980	14,100	13,180	8.5	920	6.5	1,650	150	0	1,420	80	995	80	0	875	40
1985	17,600	15,840	12.0	1,760	10.0	2,110	200	0	1,810	100	1,900	150	0	1,675	75

Sources: Columns 2, 3, 5 from "Statistics of Paper and Paperboard, 1974;" American Paper Institute, 1974, p. 6, Forecasts by Midwest Research Institute.

Column 7 from Institute of Paper Chemistry (1969); API Capacity Surveys (1970-1975); Midwest Research Institute, 1980-1985.

Column 8 from Institute of Paper Chemistry (1969); API Capacity Surveys (1970-1975); Midwest Research Institute, 1980-1985.

Note that grade of waste paper is calculated as 8 percent mixed, 88 percent container and 4 percent high grades.

(p) = Preliminary.

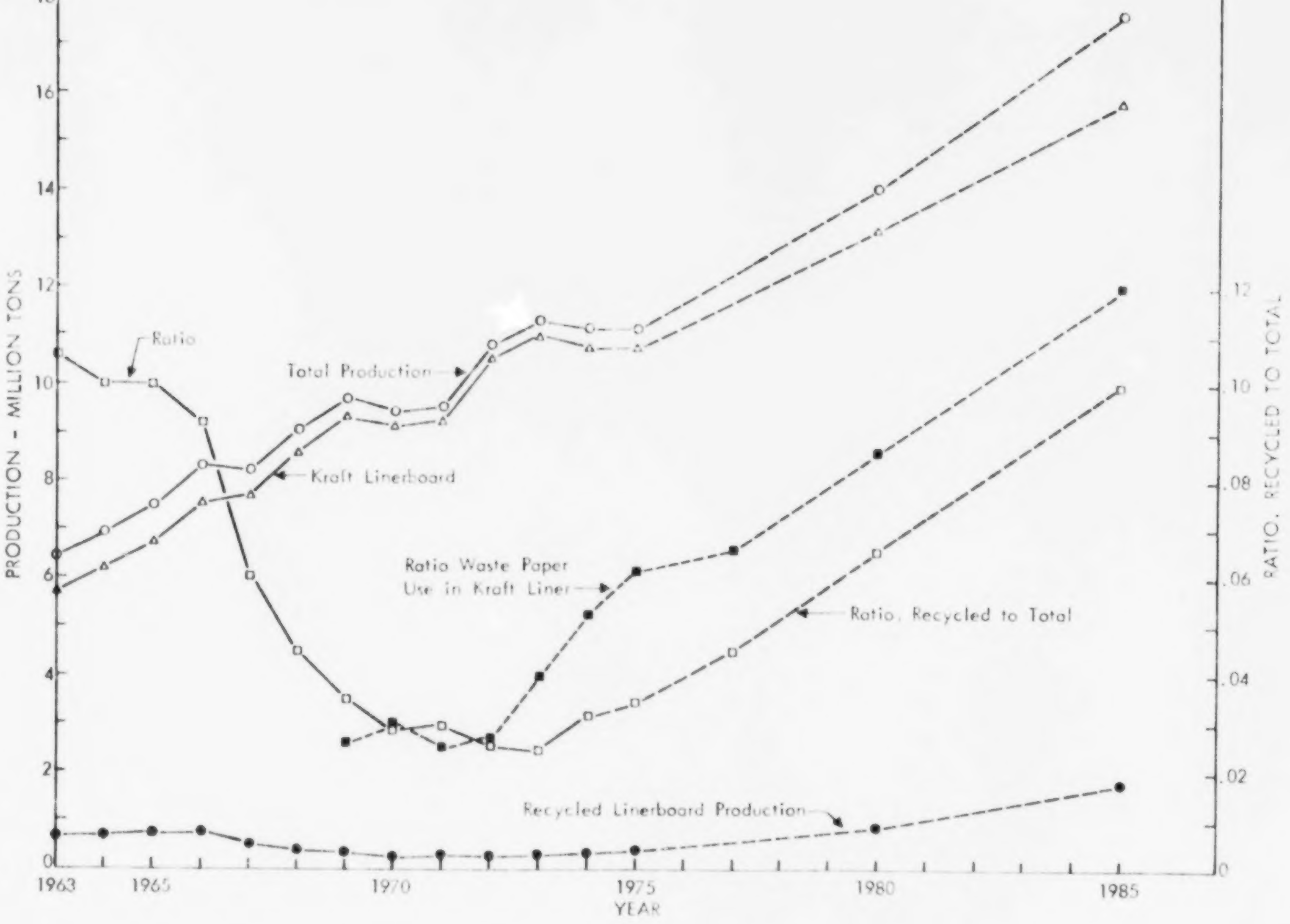

Figure E-4 - Linerboard Production, Domestic Use, and
Waste Paper, 1963 to 1985

Total output of linerboard will increase from 11.4 million tons in 1973, to 17.6 million tons in 1985, or 54 percent. In this increase, 3.25 million tons of waste paper will be used, or about one-half of the increase in demand for linerboard. Thus, this forecast is for a rather significant shift to the use of recycled fiber in linerboard compared to historical trends.

Demand and Recycling Forecasts

The outlook for linerboard demand was developed from historic trends for domestic use. The demand was then split between kraft linerboard and recycled linerboard, based upon our best estimate of raw materials availability and usage.

Recycled linerboard has been in decline for years (Table E-4, Figure E-4). However, there has been new capacity added to make recycled linerboard, e.g., Crown Zellerbach's mill at Antioch, California, and the demand trend is forecast to reverse based upon the fact that mill economics are more favorable and mill sites for new linerboard mills are very limited today. We have forecast that recycled linerboard demand will rise from 356,000 tons in 1974 to 1.76 million tons in 1985. This increase in demand is equivalent to 10 mills of 400 tons per day each (or 140,000 tons per year) output.

The demand for kraft linerboard will also increase significantly--from 11.1 million tons in 1973 to 15.8 million tons in 1985. The use of waste paper as supplemental furnish in kraft linerboard took on significance in 1975, when usage of waste paper increased to 450,000 tons from 290,000 tons the previous year. API capacity surveys show that by 1976 waste paper use will be up to 860,000 tons in kraft paperboard. By 1985, we forecast that waste paper use will be 12 percent of linerboard production, as compared to 4 percent in 1975. The basis of this forecast is that many mills can justify incremental expansions of 150 to 200 tons per day, which are economically attractive; the limitations of new kraft mill sites is also an important factor in this forecast.

The increase in annual use of supplemental furnish waste paper in kraft linerboard is 1.66 million tons between 1973 and 1985; this increase is equivalent to 31 mills adding 150 tons-per-day (53,000 tons per year) repulping installations. About one-third of this increase will take place between 1973 and 1977, according to API capacity surveys.

Linerboard is a pivotal grade in future recycling in the USA. The forecasts presented above are relatively optimistic; details of the forecasts show that the dominant source of waste paper is old corrugated containers (Table E-4). Both incremental and new mill capacity additions must aggregate about 50 percent to recycling in the next decade to reach this level of recycling.

RECYCLING IN CORRUGATING MEDIUM, 1973 TO 1985

Overview

Corrugating medium is produced in proportion to linerboard (domestic use) for use as the fluting material in boxes. There are two types of corrugating medium made--semichemical medium and recycled medium. The former is at least 75 percent virgin fiber; recycled medium is generally all recycled fiber, but may be up to 75 percent virgin pulp (which is seldom in practice). Recycling in corrugating medium has been practiced for decades and, recently, recycled medium has begun to become more important after a period of relative decline in the late 1960's.

The use of waste paper (principally box plant cuttings in semichemical and old corrugated containers in recycled medium) will increase from 1.75 million tons in 1973 to 3.18 million tons in 1985 (Table E-5, Figure E-5). This increase in waste paper use of 82 percent is heavily weighted toward recycled medium which will increase in production from 1.1 million tons in 1973 to 2.6 million tons in 1985, or 1.5 million tons. By contrast, semichemical medium, which uses about 20 percent waste paper, will increase from 4.1 million tons in 1973 to 5.5 million tons in 1985, or 1.4 million tons. While the increase in production of each type is almost evenly split, the proportion of recycled medium will increase substantially over the next decade--from 21.5 percent of total production to 32 percent in 1985.

Total output of corrugating medium will increase from 5.25 million tons in 1973 to 8.1 million tons in 1985, up 54 percent. Of this increase, over 50 percent will be recycled medium.

Demand and Recycling Forecasts

The outlook for corrugating medium demand was developed from historic trends and tied directly to the use of linerboard. The total demand was then split between semichemical medium and recycled medium, based upon our best estimate of fiber availability and economics of medium production.

TABLE E-5

CORRUGATING MEDIUM PRODUCTION, 1963 TO 1985
(In 1,000 Tons and Percent)

	Production				(6)									
				(5)	Waste Paper Use--Semichemical					Waste Paper Use--Recycled Medium				
(1) Year	(2) Total	(3) Semi Chemical Medium	(4) Recycled Medium	Percent Recycled of Total	Total	Mixed	News	Container	High Grades	Total	Mixed	News	Container	High Grades
1963	2,962	2,287	675	22.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1964	3,165	2,447	718	22.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1965	3,438	2,638	800	23.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1966	3,800	2,910	890	23.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1967	3,743	2,982	761	20.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1968	4,062	3,371	691	17.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1969	4,395	3,617	778	17.7	672	46	0	622	4	663	12	7	641	3
1970	4,264	3,405	859	20.2	754	42	28	622	62	687	11	7	666	3
1971	4,520	3,580	940	20.8	714	47	14	589	64	752	12	8	729	3
1972	4,846	3,874	972	20.1	774	82	27	608	57	778	12	7	754	3
1973	5,255	4,127	1,128	21.5	849	77	19	747	7	902	14	8	875	5
(p)1974	5,131	4,011	1,120	21.8	800	72	16	705	7	896	14	8	869	5
1975	5,130	4,010	1,120	21.8	800	70	15	710	5	896	14	8	869	5
1980	6,500	4,750	1,750	27.0	950	70	15	855	10	1,400	22	10	1,358	10
1985	8,100	5,500	2,600	32.0	1,100	70	15	1,005	10	2,080	40	10	2,020	10

Source: Columns 2, 3, 4 from Statistics of Paper and Paperboard, 1974, API, 1974, p. 6; Forecasts by Midwest Research Institute.
Column 6 from IPC (1969); API Capacity Surveys (1970-1975); Midwest Research Institute, 1980-1985.
Column 7 from IPC (1969); remainer calculated on basis of 1969 data.
(p) = Preliminary.

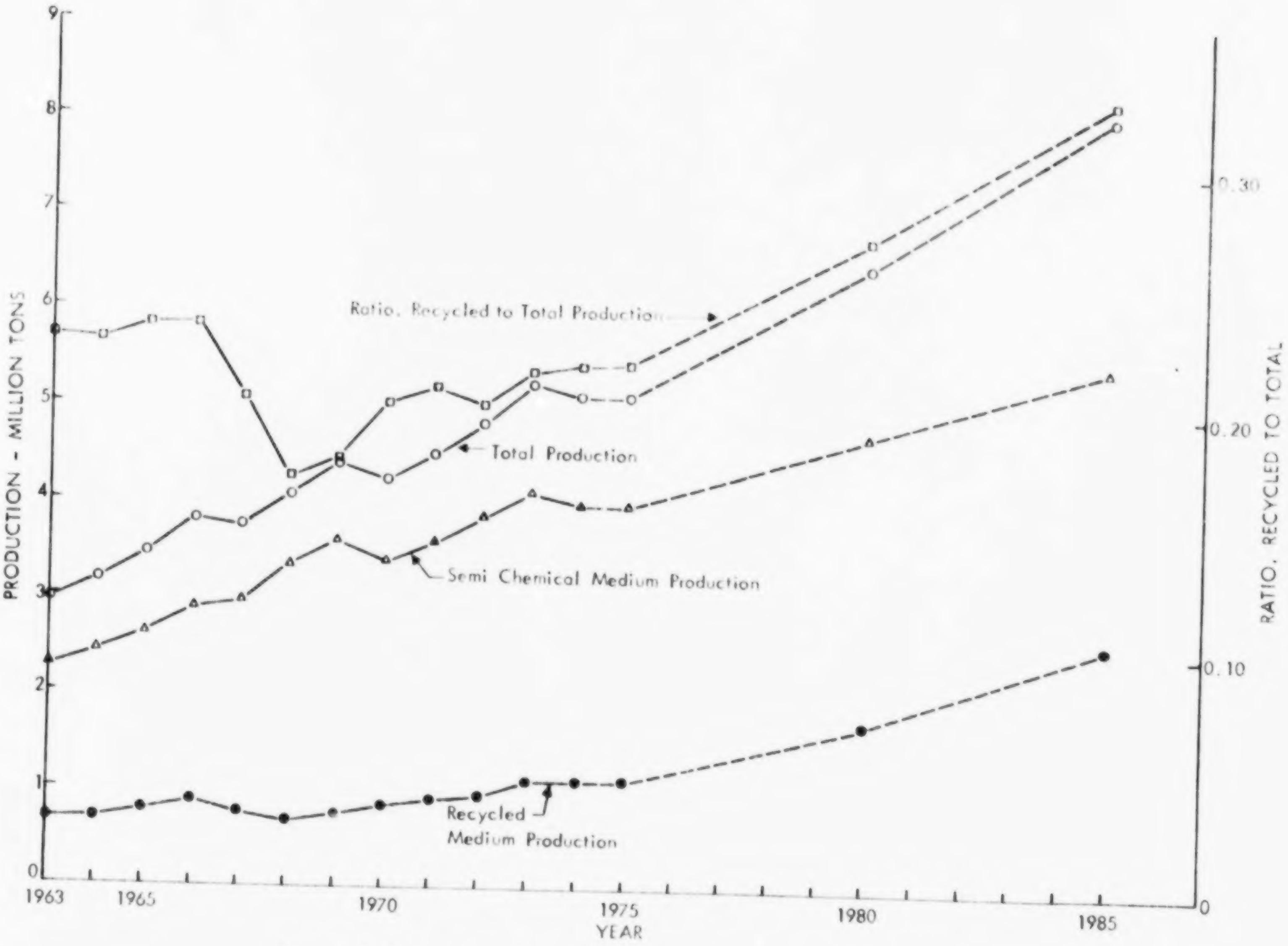

Figure E-5 - Corrugating Medium Production, 1963 to 1985

Recycled linerboard has held about 20 percent of total medium production for several years. However, the economics of recycled medium are generally favorable and several mills have converted from semichemical medium in recent years; also, new capacity to produce recycled medium is under construction (e.g., Inland Container's new mill in Indiana). The increase in demand for recycled medium forecast is 1.48 million tons per year between 1973 and 1985. This is equivalent to 12 mills of 350 tons per day output (122,000 tons per year). Note that recycled medium is not exclusively made from waste paper (Table E-5).

Semichemical medium dominates as far as tonnage is concerned--accounting for about 80 percent of total medium demand. Semichemical medium uses about 15 to 20 percent waste paper (usually box plant cuttings) routinely. Our demand forecast for recycling has been extended at 20 percent of output of semichemical medium. By 1985, semichemical medium will be at 68 percent of total medium production, compared to 78 percent in 1973. The increased output of semichemical medium is 1.4 million tons, equivalent to 10 new mills of 400 tons per day (140,000 tons per year) output.

Corrugating medium is a key grade for recycling of old corrugated containers. Although our forecasts are relatively optimistic for recycling, the waste paper should be available at competitive prices. The aggregate new demand will be slightly over one-half in recycled product between 1973 and 1985 to reach the forecast level of recycling.

FORECAST OF RECYCLING IN OTHER CONTAINERBOARD GRADES, 1973 TO 1985

Overview

Containerboard grades of paper consist of linerboard, corrugating medium, chip and fillerboard and "other grades," principally tube, can, and drum;* panelboard; exports of linerboard, medium, etc.; and gypsum wall board. In the "other" category, about 1 million tons per year is gypsum wall board, and 1.8 million tons per year is exported (mostly linerboard). This classification follows the American Paper Institute Paperboard Division statistical series.

These grades are rather diverse in nature, with exported grades (linerboard) principally virgin fiber, and gypsum wall board plus tube, can and drum, principally recycled fiber. Thus, the two major types separate into a good approximation of waste paper use, with recycled grades taking essentially all recycled fiber.

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* Only about 380,000 tons per year of tube, can and drum are produced in the containerboard category.

Total demand will increase from 3.68 million tons in 1973 to 5.8 million tons in 1985. Of this latter, 3.6 million tons will be in the virgin fiber products group, and 2.2 million tons will be recycled (Table E-6, Figure E-6). Since growth trends indicate that the two types are on similar growth patterns, the recycled grades will remain at about 38 percent of total production.

Demand and Recycling Forecasts

The trend in use of gypsum wall board and tube, can and drum paperboard favor recycled fiber products since gypsum wall board is a recycled fiber product, and tube, can and drum is trending toward recycled grades. To calculate the waste paper use, we assumed that the virgin fiber grades would use a minimal amount of waste, and that the recycled grades would require the waste paper documented by McClenahan for 1969 in gypsum linerboard--107 percent waste paper of production and the use of mixed, 22 percent; news, 23 percent; corrugated, 41 percent; and high grades, 14 percent.

On this basis, the forecast of recycling was a straightforward calculation--after total demand was forecast for each type, the use of waste paper was calculated. Waste paper use will rise from 1.48 million tons in 1973, to 2.35 million tons in 1985, or nearly 1 million tons increase (Table E-6).

FORECAST OF RECYCLING IN BOXBOARD, 1973 TO 1985

Overview

The history of boxboard production (all types) is that recycled grades have maintained total production, but all of the growth in output has gone to virgin fiber products. Thus, the recycling ratio has declined steadily since 1963, and showed no indication of reversing even in the "boom" years of 1973 and 1974.

Overall demand for boxboard is forecast to increase from 8.96 million tons in 1973 to 10.5 million tons in 1985, or a relatively modest 17 percent (Table E-7, Figure E-7). The virgin fiber boxboard production will take most of the increase--about 1.4 million tons; by contrast, recycled fiber products will increase a modest 0.2 million tons. The overall recycled boxboard percentage will decline from 51.5 in 1974 to 46.7 in 1985. Most of this decline takes place in folding boxboard.

TABLE E-6

ALL OTHER CONTAINERBOARD TYPE PRODUCTION, 1963 TO 1985
(In 1,000 Tons and Percent)

Year	Total	Virgin Fiber	Recycled	Recycled Percent of Total	Estimated Waste Paper Use Total	Mixed	News	Container	High Grades
1963	1,827	920	907	49.6	970	215	220	400	135
1964	2,191	1,262	929	42.4	995	220	230	410	135
1965	2,336	1,401	935	40.0	1,000	220	230	410	140
1966	2,451	1,531	920	37.5	985	215	225	405	140
1967	2,511	1,603	908	36.1	970	215	225	400	130
1968	3,001	1,935	1,066	35.5	1,140	250	260	470	160
1969	3,437	2,274	1,163	33.8	1,245	275	285	510	175
1970	3,345	2,271	1,074	32.1	1,150	255	265	470	160
1971	3,664	2,426	1,238	33.7	1,325	290	305	545	185
1972	3,892	2,544	1,348	34.6	1,440	315	336	590	205
1973	3,678	2,292	1,386	37.7	1,480	329	337	611	203
1974	3,577	2,248	1,329[a]	37.1	1,420	310	325	580	205
1975	3,575	2,247	1,328	37.1	1,420	310	325	580	205
1980	4,650	2,900	1,750	37.6	1,875	415	425	770	265
1985	5,800	3,600	2,200	37.9	2,355	520	540	965	330

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[a] About 73 percent of the total is gypsum liner; estimated waste paper use is based on McClenahan for gypsum liner (1969).

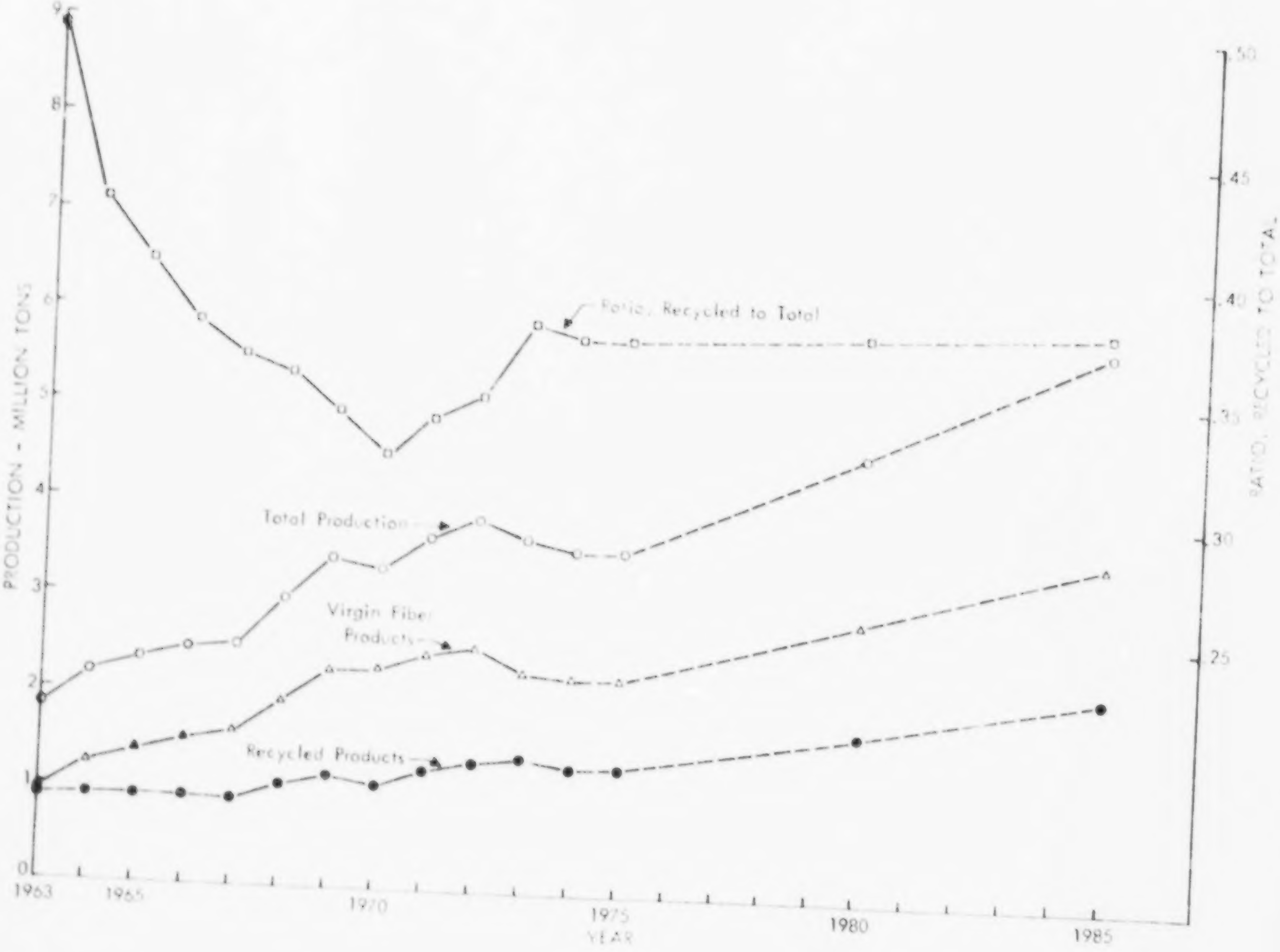

Figure I-6 - All Other Containerboard Production, 1963 to 1985

TABLE E-7

BOXBOARD PRODUCTION, 1963 TO 1985

(In 1,000 tons and percent)

(1) Year	(2) Total	(3) Virgin Fiber	(4) Recycled Boxboard	(5) Percent Recycled	(6) Total	Estimated Waste Paper Use (7) Mixed	(8) News	(9) Container	(10) High Grades
1963	7,128	2,635	4,493	63.0	5,167	1,462	1,157	1,566	982
1964	7,421	2,809	4,612	62.1	5,304	1,500	1,188	1,607	1,009
1965	7,796	3,013	4,784	61.4	5,502	1,557	1,232	1,667	1,046
1966	8,368	3,281	4,987	60.3	5,735	1,623	1,285	1,738	1,089
1967	8,060	3,279	4,781	59.3	5,498	1,556	1,232	1,666	1,044
1968	8,515	3,599	4,916	57.7	5,653	1,600	1,266	1,713	1,074
1969	8,543	3,792	4,751	55.6	5,464	1,546	1,224	1,656	1,038
1970	8,074	3,568	4,506	55.8	5,182	1,467	1,161	1,570	984
1971	8,020	3,596	4,424	55.2	5,088	1,440	1,140	1,542	966
1972	8,591	3,946	4,645	54.1	5,342	1,512	1,197	1,619	1,014
1973	8,965	4,191	4,744	53.3	5,456	1,544	1,222	1,653	1,037
1974	8,563(p)	4,152	4,411	51.5	5,070	1,435	1,135	1,535	965
1975	8,550	4,150	4,400	51.5	5,060	1,432	1,133	1,533	962
1980	9,500	4,900	4,600	48.4	5,290	1,495	1,185	1,605	1,005
1985	10,500	5,600	4,900	46.7	5,635	1,595	1,262	1,708	1,070

Sources: Columns 2 to 4, "Statistics of Paper and Paperboard, 1974," API, 1974, P. 7; Midwest Research Institute 1975-1985.

Columns 6 to 10 calculated based upon: "Consumption of Paper Stock by United States Mills in 1969 and 1970," by W. S. McClennehan Institute of Paper Chemistry, Tables V and VII.

Note: Waste paper use based upon 115 percent of production and 28.3 percent mixed, 22.4 percent news, 30.3 percent container, 19.0 percent high grades.

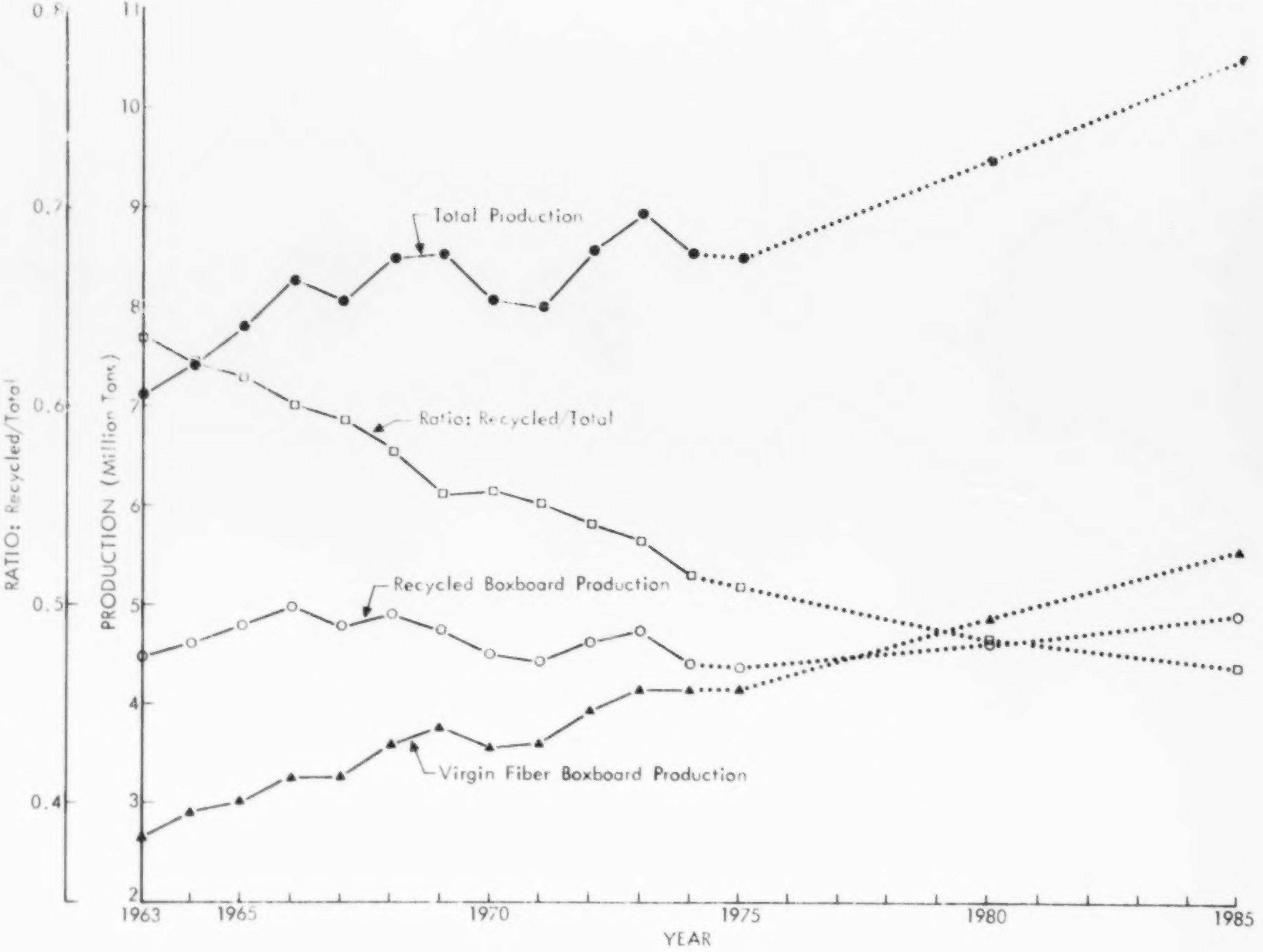

Figure E-7 - Boxboard Production, 1963-1985

A few recycled boxboard categories such as tube, can and drum paperboard (included in "other boxboard") are showing significant increases in the use of recycled fiber. However, these increases are masked by relative declines in the major boxboard categories, especially in folding boxboard.

Boxboard has little overlap in the mixing of virgin and recycled fibers in specific grades--in other words, a product is usually made of one or the other. Thus, once a demand forecast has been developed, it is relatively simple to calculate waste paper use in recycled grades.

The basis for the waste paper calculation was the waste paper use data developed by McClenahan for 1969 (see Table E-7 for the details). The requirements for waste paper will rise from 5.45 million tons in 1973 to 5.63 million tons in 1985. Thus, without a major shift in trend away from the use of virgin fiber products, boxboard products will be a stable to very modest growth area for recycling.

The distribution of boxboard by type is given for 1980 and 1985 in Table E-8. As shown, the growth potential in recycled types (set up, folding, and other) is quite modest.

TABLE E-8

BOXBOARD PRODUCTION BY TYPE, 1980 AND 1985
(in thousand tons)

	Total Boxboard	Folding Boxboard	Set Up	Milk and Food	All Other
1980 Total	9,500	4,950	440	1,760	2,350
Recycled	4,600	2,330	440	0	1,830
Solid	4,900	2,620	0	1,760	520
1985 Total	10,500	5,500	440	1,960	2,600
Recycled	4,900	2,480	440	0	1,980
Solid	5,600	3,020	0	1,960	620

Source: Midwest Research Institute forecasts.

FORECAST OF RECYCLING IN FOLDING BOXBOARD, 1973 TO 1985

Overview

About one-half of all boxboard produced is folding boxboard. Thus, the trend in recycling in folding boxboard influences the trend for the broader category. The actual tonnage output of recycled folding boxboard has declined slightly in recent years, and all growth in demand has gone to the virgin fiber type boxboard. Thus, the percentage of recycled has declined rapidly--from 70.5 percent in 1963 to 51.9 percent in 1974 (Table E-9).

This decline has dampened the outlook for recycling in boxboard because most of the relative growth in recycling in other types of boxboard (e.g., tube, can and drum) is more than offset by the decline in importance of recycled folding boxboard.

Folding boxboard mills tend to be the older cylinder machine operations that compete principally for "custom" packaging and heavier weights of boxboard. In addition, the virgin fiber type has captured much of food packaging and high volume uses. There is also substantial new capacity on the way (about 700,000 tons per year net gain) in both bleached and unbleached paperboard; this will favor the continued use of virgin fiber products in the next decade.

For these reasons, it is difficult to build a case for a resurgence of recycling in the folding boxboard grades. Our forecast reflects a slowing of the decline rate, but not a flattening out of the ratio over time (Figure E-8, Table E-9). The crossover point (i.e., where production of virgin and recycled are the same) will occur in 1976 or 1977. Since the use of waste paper is tied directly to the fortunes of recycled folding boxboard, it follows that under these conditions the demand for waste paper in the folding boxboard grades will stabilize, but not increase significantly.

Our forecast is that waste paper demand will be essentially the same in 1985 as in 1973 (Table E-9). Thus, the relatively pessimistic outlook for recycling in one of the traditional recycling grades of boxboard leads to an overall recycling rate in boxboard that is stable, but not growing.

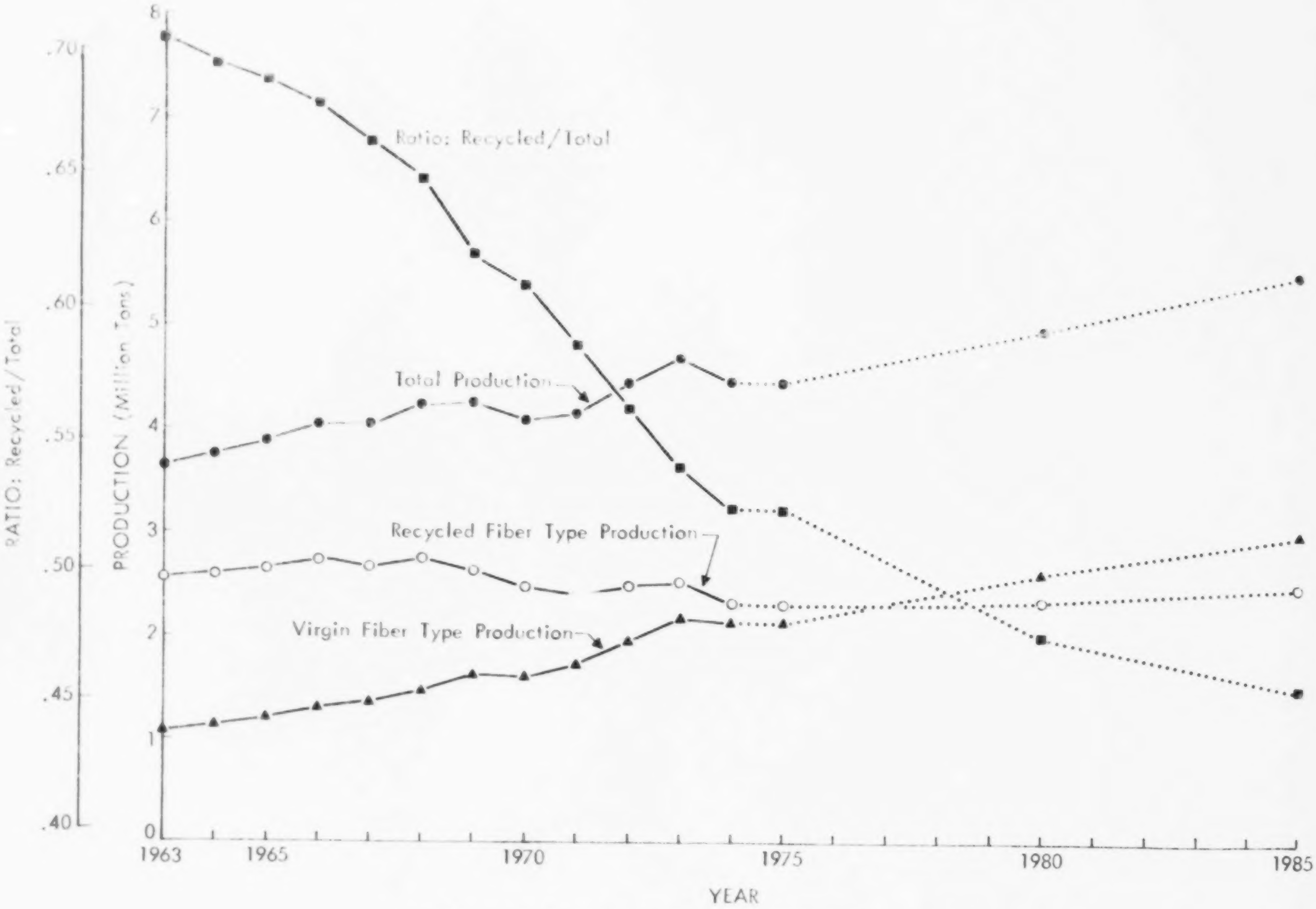

Figure E-8 Folding Boxboard Production, 1963-1985

TABLE E-9

FOLDING BOXBOARD PRODUCTION, 1963 TO 1985

(in 1,000 tons and percent)

(1) Year	(2) Total	(3) Virgin Fiber	(4) Recycled	(5) Percent Recycled	Estimated Waste Paper Use (6) Total	(7) Mixed	(8) News	(9) Container	(10) High Grades
1963	3,636	1,074	2,562	70.5	2,946	834	660	893	559
1964	3,752	1,159	2,594	69.1	2,983	844	668	904	567
1965	3,880	1,221	2,659	68.5	3,058	865	685	927	581
1966	4,040	1,308	2,732	67.6	3,142	889	704	952	597
1967	4,021	1,361	2,660	66.2	3,059	886	685	927	581
1968	4,218	1,488	2,730	64.7	3,140	889	703	951	597
1969	4,262	1,633	2,629	61.7	3,023	856	677	916	574
1970	4,080	1,607	2,473	60.6	2,844	805	637	862	540
1971	4,139	1,732	2,408	58.2	2,769	784	620	839	526
1972	4,440	1,963	2,477	55.8	2,849	806	638	863	542
1973	4,705	2,184	2,522	53.6	2,900	820	650	880	550
1974	4,449(P)	2,141	2,308	51.9	2,655	750	595	805	505
1975	4,450	2,142	2,308	51.9	2,655	750	595	804	505
1980	4,950	2,620	2,330	47.0	2,680	758	600	812	510
1985	5,500	3,020	2,480	45.0	2,852	807	640	864	541

Sources: Columns 2 to 4, "Statistics of Paper and Paperboard, 1974," API, 1974, p. 17; Midwest Research Institute. forecasts 1975-1985.

Column 6 to 10 calculated based upon: "Consumption of Paper Stock by United States Mills in 1969 and 1970," by W. S. McClennehan Institute of Paper Chemistry, Tables V and VII.

Note: Waste paper use based upon 115 percent of recycled grades production and 28.3 percent mixed, 22.4 percent news, 30.3 percent container, 19.0 percent high grades.

WASTE PAPER RECOVERY BY GRADE, 1972 TO 1990

The basis of waste paper use is derived from: (1) basic paper product demand by type, (2) the potential for recycling in each major grade (e.g., linerboard); and (3) the actual forecast of recycling in each grade. Once (3) above is established, it is also necessary to look at the grade structure of waste paper for each recycling application.

The principal reference for determining the amount and grade distribution of waste paper for each recycling application was the McClenahan work referenced frequently in this study (for 1969). In addition, it was possible to obtain the same data in a less detailed, but useful way, from the API capacity surveys covering waste paper use for the years 1970 through 1973. In particular, the latter sources were useful where waste paper is used in predominantly virgin fiber products, e.g., kraft paperboard. For the myriad of recycled paperboard grades, we relied on the McClenahan data for detail because only the total waste paper use by grade is given for recycled paperboard by API statistics. Nonetheless, these two sources were the basis of developing the detailed grade structures for waste paper in Table 107 and this appendix.

The distribution of waste paper use by waste grade in each paper grade was calculated from the McClenahan data. The results are given in Table E-10.

Likewise, the summary of usage of waste paper by grade was developed in a similar manner and is given for the years 1970 to 1990 in Table E-11.

Finally, when all uses of waste paper, including exports, are considered, the total demand for waste paper by major grade category was determined (Table E-12). These data simply add to recycling the anticipated exports (distributed to the same grades as domestic recycling) of waste paper for the years 1972 to 1990.

Table [illegible]

DISTRIBUTION OF WASTE PAPER USE BY GRADE BY PAPER GRADE, 1969

End Use Category	Total Production	Total Waste Paper Use	Ratio of Waste Paper To Product	Mixed	Percent Mixed of Total	News	Percent News of Total	Container	Percent Container of Total	Pulp Substitutes	Percent Pulp Substitute of Total	Deinking	Percent Deinking of Total
Paperboard													
Combination boxboard and chipboard	4299	4963	115	1402	28.3	1113	22.4	1506	30.3	730	14.9	203	4.1
Recycled linerboard	402	436	108	36	8.3	--	--	382	87.6	17	3.9	1	[illegible]
Recycled medium	939	663	71	12	1.8	7	1.0	641	96.7	1	0.2	2	0.3
Linerboard/boxboard (kraft)	12903	259	2	22	8.5	--	--	210	81.1	27	10.4	--	--
Semi-chemical medium	3547	672	19	46	6.8	--	--	622	92.6	4	0.6	--	--
Tube, can and drum	733	646	88	106	16.4	116	18.0	349	54.0	71	11.0	4	0.6
Gypsum linerboard	847	903	107	201	22.2	206	22.8	373	41.3	118	13.1	5	0.6
Total paperboard[a/]	26069	8583	33	1830	21.3	1445	16.8	4100	47.8	988	11.5	220	2.6
Other Paper and Paper-Board													
Construction	1603	1134	71	695	61.3	198	17.5	217	19.1	24	2.1	--	--
Wet machine board	148	96	65	77	80.2	--	--	9	9.4	10	10.4	--	--
Paper													
Printing, writing and related	14499	850	6	--	--	372	43.8	8	0.9	250	29.4	220	25.9
Packaging and industrial conveyance	5078	131	3	3	2.3	3	2.3	15	11.5	90	68.7	20	15.3
Special industrial	443	34	8	1	2.9	--	--	23	67.6	10	29.4	--	--
Tissue	3575	962	27	7	0.7	38	--	62	--	513	--	347	--
Total Paper	23595	1977	8	6	0.3	413	20.9	85	4.3	876	44.3	597	30.2

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a/ Detail on food board and miscellaneous omitted

Source: "Consumption of Paper Stock by United States Mills in 1969 and 1970", W. S. Mc[illegible], Tables V, VI, VII, and VIII.

TABLE E-11

ESTIMATED USAGE OF WASTE PAPER FOR RECYCLING IN THE PAPER INDUSTRY BY MAJOR GRADE CATEGORY, 1972-1990
(In Thousand Tons)

Waste Paper Grade	1970	1971	1972	1973	1975	1980	1985	1990
Mixed Grades	2,639	2,776	3,054	3,251	3,215	3,670	4,185	4,510
News--post-consumer	1,825	1,754	1,880	2,129	2,110	2,535	2,985	3,375
News--converting[a]	410	420	437	450	440	500	560	625
Total	2,235	2,174	2,317	2,579	2,550	3,035	3,545	4,000
Corrugated--post-consumer	2,528	2,700	2,960	3,430	3,410	5,100	7,425	10,085
Corrugated--cuttings[b]	1,552	1,577	1,762	1,861	1,820	2,305	2,870	3,565
Total	4,080	4,277	4,722	5,291	5,230	7,405	10,295	13,650
Deinking Grades and Pulp Substitutes	3,067	3,097	3,037	3,198	3,165	3,750	4,440	5,180
Grand Total	12,021	12,323	13,132	14,318	14,160	17,860	22,465	27,340
Paper Demand	57,835	59,440	64,356	67,122	66,490	79,360	93,565	109,240
Recycling Rate	20.8	20.7	20.4	21.3	21.3	22.5	24.0	25.0

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a/ Based upon calculated printing scrap recovery of 2.8 percent of newsprint demand plus overissue news at 1.4 percent of newsprint demand.

b/ Based upon 11.0 percent of containerboard mill production (domestic use); calculated from McClenahan data for cuttings 1969, 1970.

TABLE E-12

CALCULATION OF WASTE PAPER RECOVERY BY GRADE, 1972-1990
(In thousand tons and percent)

Grade Category	1972			1975			1980			1985			1990		
	Recycling Only[a]	Percent	Total Recovery[b]	Recycling Only[a]	Percent	Total Recovery[b]	Recycling Only[a]	Percent	Total Recovery[b]	Recycling Only[a]	Percent	Total Recovery[b]	Recycling Only[a]	Percent	Total Recovery[b]
Mixed	3,056	23.3	3,155	3,215	22.7	3,440	3,670	20.5	3,905	4,185	18.6	4,435	4,510	16.5	4,785
News	2,317	17.6	2,385	2,550	18.0	2,725	3,035	17.0	3,240	3,545	15.8	3,770	4,000	14.6	4,235
Container	4,722	36.0	4,880	5,230	36.9	5,590	7,405	41.5	7,905	10,295	45.8	10,925	13,650	49.9	14,470
Pulp Subs	2,100	16.0	2,165	2,150	15.2	2,305	2,540	14.2	2,710	3,000	13.4	3,195	3,525	12.9	3,740
Deinking	932	7.1	965	1,015	7.2	1,090	1,210	6.8	1,290	1,440	6.4	1,525	1,655	6.1	1,770
Total	13,137	100.0	13,550	14,160	100.0	15,150	17,860	100.0	19,050	22,465	100.0	23,850	27,340	100.0	29,000

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a/ Recycling in the paper industry (fiber use).

b/ Recovery of fiber for all uses including net exports. Recovery by grade based on same percentage as for recycling in the paper industry.

Source: **Midwest Research Institute.**

BASIS FOR CALCULATION OF END USES, CONVERTING SCRAP, PAPER DISCARD PATTERNS AND SOURCE OF WASTE PAPER GENERATION

The following data are the basis on which the calculations of Tables 93 to 99 and Tables 100 to 104 in Chapter 10 were developed.

Newsprint:

1. About 7 percent goes into non newspaper uses such as publishing; the balance is used in newspapers.

2. Converting scrap is estimated on the following basis: Seventy-five percent of consumption is in large newspapers experiencing about 2.7 percent scrap rate.

Twenty-five percent of consumption is in small newspapers or publishing experiencing about 8 percent scrap rate.

$$0.75 \times 0.027 + 0.25 \times 0.08 = 0.04$$

Twenty-five percent of demand is estimated to be overissue newspaper; about 1.5 percent is recovered for recycling based on McClenahan data for 1969/1970.

3. The characteristics of newsprint entry into solid waste is estimated as follows: (See also "Nonpackaging Paper" Tables 26 and 34, and page 56.*)

0.5 percent is lost or diverted to uses that do not enter waste.

0.5 percent of current consumption is retained in files or held long enough to show a delay in entry to waste compared to current demand. Thus, 1.0 percent is diverted/delayed, and 99.0 percent of current consumption quantity enters municipal waste.

4. Household is estimated at 90 percent of net demand; 10 percent is estimated as commercial/industrial waste, e.g., commercial newspapers and printing (Wall Street Journal, etc.). There was no documented basis for this split. Discard patterns will differ from city to city, e.g., where street sales of paper are high, discard in commerical waste will be higher; however, most newspapers are discarded from the home.

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* The Role of Nonpackaging Paper in Solid Waste Management, 1966 to 1976, U.S. Environmental Protection Agency, Solid Waste Management Office, Publication SW 26c (1971)

Printing Papers:

1. The principal uses for printing paper are: catalogs and directories, magazines, books, commercial printing, and converted paper products, with commercial printing and magazines the dominant categories. Some of these products have a retention value, but most printed products except certain types of books are discarded within a few years of manufacture at the most; some books are removed more or less permanently from the waste stream, going into permanent retention.

2. Converting scrap in printing operations usually amounts to 15 to 18 percent for magazines, periodicals, catalogs, etc. We used 12 percent as the basic converting scrap factor, thus making allowance for lower scrap rates in other types of printing paper.

3. The characteristics of printing paper is estimated as follows: (See also "Nonpackaging Paper" Tables 27 and 34, and pages 56 and 58). About 30 percent of books go into more or less permanent storage, but less than 5 percent of the other printing grades are permanently retained. There is some delay of entry into the waste stream because of retention of materials for 1 to 5 years. Overall, the ratio of current consumption entering the waste stream in any 1 year is about 0.89.

4. A majority of printed materials end up in the home--as catalogs and directories, e.g., mail order and telephone books; as magazines, as books; as direct mail advertising and other printed materials. However, the same end uses apply to nonhousehold. Overall, we estimated that 60 percent of the total is household waste and 40 percent is nonhousehold (commercial/industrial). Because of the diversity of uses, no firm basis could be developed for making the split.

Fine Papers:

1. The principal uses of fine paper are writing paper, reproduction paper, and other communication types of paper. Writing paper makes up over 50 percent of the total office uses.

2. Converting scrap ranges from an estimated 5 percent to 12 percent, depending on the converted product, e.g., business forms and in-house reproduction have a higher scrap rate than stationary converting. Overall, an average of 8 percent scrap rate was used.

3. Certain types of paper have a permanent retention value, e.g., bristols used for library cards, some types of records. For the most part, permanent retention is less than 10 percent. Many types of fine paper are retained from 2 to 10 years before discard. The combined effect of permanent retention and delayed discard led to a ratio of 0.87 of annual tonnage to be discarded. (See also "Nonpackaging Paper," Tables 28 and 34, and page 58).

4. The fine paper grades are generally business type papers--forms, stationery, computer printout, etc. We estimate that 80 percent ends up in nonhousehold and 20 percent in homes.

Industrial Converting and Packaging Paper:

1. These grades consist primarily of wrapping paper, shipping sacks and grocery bag paper, and other converting paper, e.g., file folders, plus industrial paper, e.g., filter paper. Thus, the product characteristics are such that a short life span for the product is to be expected with discard essentially "as used". Some industrial paper goes into cable, gaskets, insulation and the like, which "disappears" as a paper product from the paper waste stream.

2. Because the greatest tonnage is in high volume converting, we estimate the scrap rates to be 2 percent to 10 percent, with the average about 5 percent.

3. Some special use grades are diverted into other types of waste and some delay in discard occurs. However, we estimate that about 98 percent of current tonnage ends up being discarded rather promptly.

4. The packaging grades of paper are split between household and nonhousehold. The largest quantities go into bag and sack paper and wrapping paper (retail stores packaging products to carry to the home); and shipping sack and other uses which are largely nonhousehold uses. Overall, we estimate 65 percent is household and 35 percent is nonhousehold.

Tissue:

1. The principal uses for tissue are: toilet paper, facial tissue, towels, napkins, wipers, and wrapping tissue. Of these, toilet tissue constitutes about 35 percent, which "disappears" from the solid waste stream into sewer systems. Some other tissue is disposed of in nonconventional manners too, such as burning or sewer.

2. There were no real guideline data available for estimating converting scrap rates for tissue. We estimate the conversion scrap to fall between 3 and 8 percent; 5 percent was used.

3. Almost all tissue products are used once and then discarded; that is the nature of the products. Thus we believe that tissue enters the waste stream essentially as produced. Toilet tissue is discarded into sewer systems. The discard profile was estimated as 0.62 with 0.35 being "diverted" toilet paper and 0.03 being other "diverted" discard.

4. Tissue products are personal use products associated with human activities. Thus, a function of waste generation is where the persons are when the products are used. Facial tissue is largely a home use item--about 80 percent we estimate. Napkins are used for eating--about 67 percent in home and 33 percent nonhousehold. Paper towels are probably about 80 percent a household item. Wipers are a nonhousehold product used in commercial/industrial applications. Based on a calculation by end uses for 1972, a split of 70 percent household and 30 percent nonhousehold was used.

Containerboard:

1. About 95 percent of linerboard, medium and chipboard is used to make shipping containers for a multitude of products and purposes. While some products can go into a long inventory cycle, the containerboard has generally served its purpose in a matter of weeks or months and is discarded.

2. The conversion scrap rates varies for containerboard from perhaps 5 percent to 15 percent, depending upon the configuration of the box. The average is probably about 8 to 9 percent. However, we have used 11 percent scrap rate because this can be documented in the McClenshan[1/] references wherein containerboard cuttings reported to be used in recycling were equal to 10.8 to 11.1 percent of containerboard production for 1969 and 1970. While some other materials, e.g., bag wastes are probably reported as corrugated cuttings, this is still a sound basis on which to relate scrap production for this category.

3. Containerboard enters the waste stream as produced and we estimate a nominal 0.02 is diverted from waste; 0.98 is discarded to solid waste in the year produced and used.

4. Containerboard products, i.e., corrugated shipping containers are discarded where the product is unpacked. For the most part, this is in commercial and industrial establishments. Based upon the Fibre Box Association's "Classification of Shipments by End Use, 1970-1973," (page 24, "Fibre Box Industry Annual Report, 1973") it was estimated that 68 percent of containers are discarded in commercial establishments (retail stores, warehouses, etc.) and 32 percent in industrial plants (auto assembly plants, electronics plants, etc.). Some boxes reach households via mail order purchases and are retrieved by the residents. We estimate no more than 10 percent of the boxes in the commercial category do so. Thus, the final allocation was: household, 7 percent; commercial, 61 percent; and industrial, 32 percent (93 percent nonhousehold).

[1/] Op. Cit.

Other Containerboard:

1. The principal products are gypsum wallboard (about 1 million tons per year), tube, can and drum (abour 400,000 tons per year); the balance is panelboard and other containerboard type paper.

2. The conversion scrap rate is unknown, and the products are diverse in nature. We estimate scrap rates are in the order of 5 to 10 percent; we have used 7 percent.

3. About 1/2 the tonnage goes into construction products (gypsum wallboard) and durable goods (panelboard). This is diverted from the mixed municipal waste stream in discard. We estimate about 10 percent enters the municipal waste stream in identifiable form; the remainder is in construction debris, junked autos, appliances and the like. The other 1/2 of the category is in uses that become discards rapidly (e.g., tube, can, drum) and here we estimate only 10 percent is diverted to other uses and 90 percent discarded to municipal waste streams. The calculation for municipal waste is: Discard = .50 x .10 + .50 x .90 = .50. Thus, .50 is diverted.

4. Other containerboard discard patterns could not be accuarately assessed. We estimated 50 percent household and 50 percent nonhousehold discard.

Folding Boxboard:

1. The principal use is folding cartons for a multitude of products; some is used in various other uses that are only vaguely documented by paper industry sponsors, e.g., game boards.

2. Conversion scrap has been estimated for years by the Paperboard Packaging Council at 19 percent of carton input tonnage. We estimate a scrap rate for noncarton uses of 10 to 15 percent. The composite scrap rate is estimated at 18 percent, based upon McClenahan[1] data for use of boxboard cuttings in 1969/1970, compared to boxboard production in those years.

3. Boxboard is discarded as produced and used; some inventory of product takes place, but this is minor. We estimate that a nominal 2 percent is diverted and 98 percent is discarded to the municipal waste stream.

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[1] Op. Cit.

4. Folding boxboard is used principally for cartons and thus is predominantly a retail sales package; most of it is discarded in the home where the contents are used. Thus, we estimate that 80 percent is household and 20 percent is nonhousehold.

Setup Boxboard:

This is used for heavy weight boxes, e.g., shoes, candy, hosiery, etc. Its profile is similar to folding boxboard. We estimate 10 percent scrap and 90 percent discard to municipal waste.

Setup boxboard is used almost exclusively in retail sales packages. We estimate 90 percent is discarded from the home and 10 percent in nonhousehold locations.

Milk and Food Service:

1. The principal uses are milk cartons, food cartons, food cups, plates, and miscellaneous uses of which nonpacking is about 100,000 tons per year.

2. The conversion scrap rate is estimated in the range of 10 to 15 percent. This scrap is solid bleached sulfate and serves as pulp substitute grade. We used 12 percent.

3. All of these products are short life products and discarded promptly. Thus, we estimate essentially 100 percent discard to waste.

4. Milk and food service is predominantly food packaging and, thus, is discarded where the contents are emptied--at home or food service locations. On the basis that 70 percent of meals are eaten at home and 30 percent away, we split the discard between household and nonhousehold.

Other Boxboard:

1. This category consists of tube, can and drum paperboard (made in boxboard mills) about 700,000 tons per year, and miscellaneous uses of up to 1 million tons per year. Many of the latter uses are heavyweight products, e.g., publishers book, cardboard, nonbending board, etc.)

2. The conversion scrap rate is estimated to range from 5 to 15 percent, but no data base is known; we used 10 percent because this is an average for converting type operations.

3. Tube can and drum paperboard is used and discarded even though some industrial drums are returnable and reused several times. Some of the miscellaneous uses go into industrial or consumer products, e.g., books, that have a permanent retention value. The category is too diverse to make more than an estimate: 15 percent diverted from the paper waste stream; 85 percent entry municipal solid waste systems.

4. Other boxboard is classified into miscellaneous uses that cannot be accurately assessed from a solid waste standpoint. We estimated 50 percent household and 50 percent nonhousehold.

Wet Machine Board and Construction Paper:

1. These products are used for shoe board, book bindings, and construction paper such as roofing felts. Thus, a high percentage is diverted from the identifiable mixed waste stream and shows up as a part of construction debris, "leather" shoes, and the like.

2. Conversion scrap is probably 5 to 15 percent, depending on the product. We used 8 percent.

3. The diverted category is estimated at 90 percent of the total demand; that entering mixed waste as an identifiable paper product is thus 10 percent. (See also "Nonpackaging Paper," Tables 32 and 34 and page 60).

4. Construction paper is a minor cateogory and the waste discard was classified as 50 percent household and 50 percent nonhousehold (most of which is related to construction activity). There is no published basis on which to make a split.

Insulating and Hard Pressed Board:

1. These products are used for building construction and in industrial and consumer products, e.g., applicances, furniture, autos, panels, etc. About half of this goes into buildings, but the other applications are growing more rapidly in use. Many times there are wood wastes (sawdust) mixed with an epoxy.

2. Conversion scrap is probably 5 to 15 percent, depending upon the specific product being made. We used 8 percent.

3. The diverted category is estimated at 90 percent of total demand because these products are viewed in solid waste as part of special waste categories, e.g., construction debris, appliances, etc. That entering

municipal waste in an identifiable form is estimated at 10 percent. (See also "Nonpackaging Paper," Tables 32 and 34, and page 60.)

4. Insulating and hard pressed board is a minor category in which waste discard was classified as 40 percent household and 60 percent nonhousehold. There is no published basis on which to make a split.

APPENDIX F

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